Radio Control

HANDBOOKS

INSTALLING RADIO CONTROL EQUIPMENT

Peter Smoothy

INSTALLING RADIO CONTROL AIRCRAFT EQUIPMENT

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Installing Radio Control Aircraft Equipment

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Dedication

To my wife Ann who, throughout 21 years of marriage has tolerated the smell of dope, oily overalls, superglue on the carpet, committee meetings in the lounge, long days on cold airfields . . . and me . . . and usually smiled.

Acknowledgements

I would like to thank the following for their help and advice in producing this little book:

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Introduction

SOME 26 YEARS ago when I purchased my first ever proportional radio outfit I paid a price that, in actual pounds and pence, was very similar to today's prices. In real terms, of course, it was far more expensive than modern equipment, costing far more, as a percentage of my hard earned salary, than a similar outfit would cost today. Modern radio is not only comparatively cheaper but infinitely more reliable than were those early sets. Most of the 'bugs' have been ironed out and while occasionally one still hears about the odd genuine rogue set, reliability is good. But, however good the equipment may be, it will count for nought if it is badly installed and poorly maintained. The careful application of sound construction methods is essential if longevity is the aim.

The prospect of installing the equipment may be daunting to the newcomer, yet given a logical approach it is not difficult. In this book you will find all you need to know to complete your installation. Read the book through from cover to cover before you start and keep it close by, in the workshop, for easy reference.

Aviation, be it model or full-size, operates in a hostile environment, but modern equipment, sound techniques and just a little luck should ensure that any model aircraft enjoys a long life and gives you, its owner, many hours of solid pleasure.

By now you may have purchased your modern equipment, the sound techniques are in the book, but you may have to arrange your own good luck . . .

1988 Peter Smoothy

Chapter 1
Hingeing the Flying Surfaces

IMPROVEMENT in the art of injection moulding over the last ten years or so has enabled the industry to supply the modeller with a whole range of accurately made plastic accessories, which has made the construction of a model aircraft infinitely easier. Hinges are no exception and, although the choice is wide and varied, the basic types of hinge for model construction number just five. Whichever type of hingeing method is chosen, the requirements are the same.

1. The hinged control surface must be easy moving. Stiffness or sticking is not acceptable and may result in a model that is difficult to control and impossible to trim. It will also mean that the servo has to work harder, resulting in higher current consumption (and henceforth lower battery life) and of course greater wear and tear.

   A good guide to freedom of movement is that a well-constructed hinge system will allow the control surface to fall under its own weight once the pushrods have been disconnected.
2. The gap between the two surfaces, e.g. fin and rudder or wing and aileron, must be as small as possible. Much aerodynamic efficiency will be lost if this gap is too large and large gaps add nothing to the aesthetic standards of the model.
3. The hinge must be strong enough for the job in hand. Generally extra strength is added by adding extra hinges. Strength also comes from a well-fixed hinge and much care needs to be taken in this department as many models have been lost due to insecure hingeing.

The Sewn Hinge

This form of hinge hardly owes its existence to modern technology! This is the original hinge which dates back to the very earliest days of aeromodelling.

Unsightly and undesirable on scale models, it adds character and authenticity to the vintage flying machine. Cheap and easy to make, it provides a slop-free installation if adequate care is taken.

The diagram opposite illustrates the method used and, of course, like most hingeing techniques, it is done *after* the flying surfaces have been covered. Use a heavy type of thread, not the dressmaking varieties used for domestic sewing applications. I personally have had great success with threads obtained

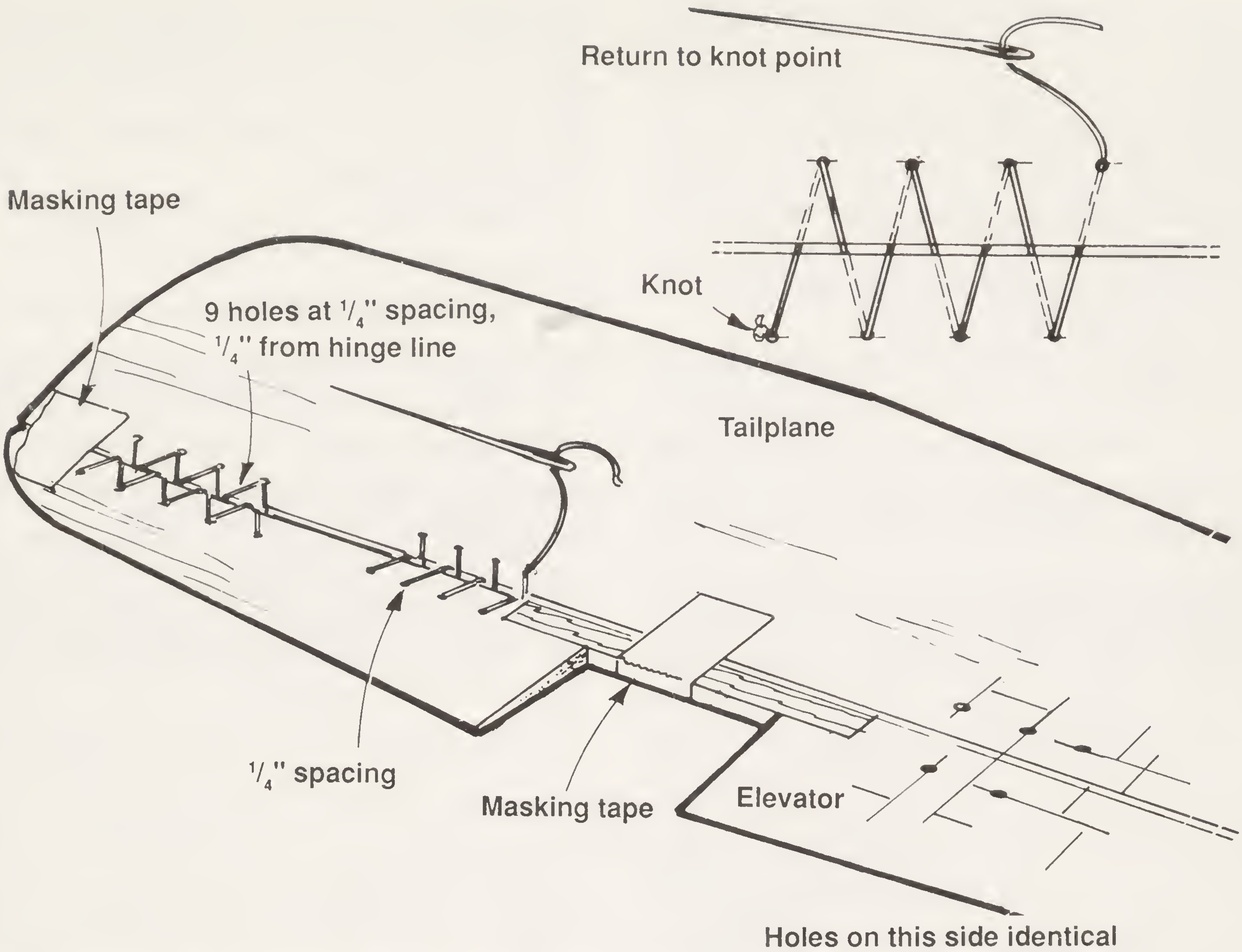


Fig. 1.1 Sewn thread hinges. Note the use of adhesive tape to hold alignment.

from carpet shops and upholstery supplies. Whatever you choose should be thicker and stronger than the household type but still thin enough to thread through the eye of an ordinary sewing needle.

Mylar Strip Hinges

Mylar is a tough plastic material which flexes easily. The type used for control surface hingeing is usually 1in. wide strip, the Mylar being just 0.010in. thick (0.25mm). Because the material is available in strip form the modeller is able to choose his own hinge width. As a general guide, strips 12mm wide are quite suitable for models up to about 60in. span. For larger models the hinge width should be increased to about 18mm.

One Piece Polypropylene Hinges

Polypropylene is a material which is very similar in feel and flexibility to Mylar. The material used for hinges is much thicker (0.50mm) than Mylar strip and the hinge line is formed by a moulded waist, or thin point, to allow sufficient flexibility.

With all types of hinges accurate alignment is essential and Mylar and poly hinges are no exception. Once the hinge position has been accurately marked, the slot must be cut into the flying surface to accept 'its' half of the hinge. Initially a sharp modelling knife is used to penetrate the wood but even the thinnest of hinge materials require this slot to be opened up to accept the hinge. A fine file or the disposable nail sander from your lady's handbag can be used, but a broken junior hacksaw blade used

carefully is also very effective and costs nothing.

Once the slots have been cut the flying surface can be assembled. Mylar hinges are smooth and do not readily bond with adhesives so roughen up the hinge tongue with fine glasspaper or, better still, puncture the tongue in several places with a pin.

Glueing the hinges in place must be done with great care to avoid adhesive contaminating the hinge line and ruining the freedom of movement. This warning particularly applies where epoxy is used.

Modern cyanoacrylate adhesives, particularly the 'thin' variety, are also extremely useful for fixing hinges. The sequence adjoining illustrates a method that has served me well over the years although the more cautious may wish to pin both surfaces.

Pinned Pivot Hinges

The improved injection moulding techniques mentioned earlier have given the modeller a vast range of hinges of this type from which to select the one most applicable to the job in hand.

Generally, fitting is very similar if not identical to fitting Mylar type hinges and, again, it must be emphasised that

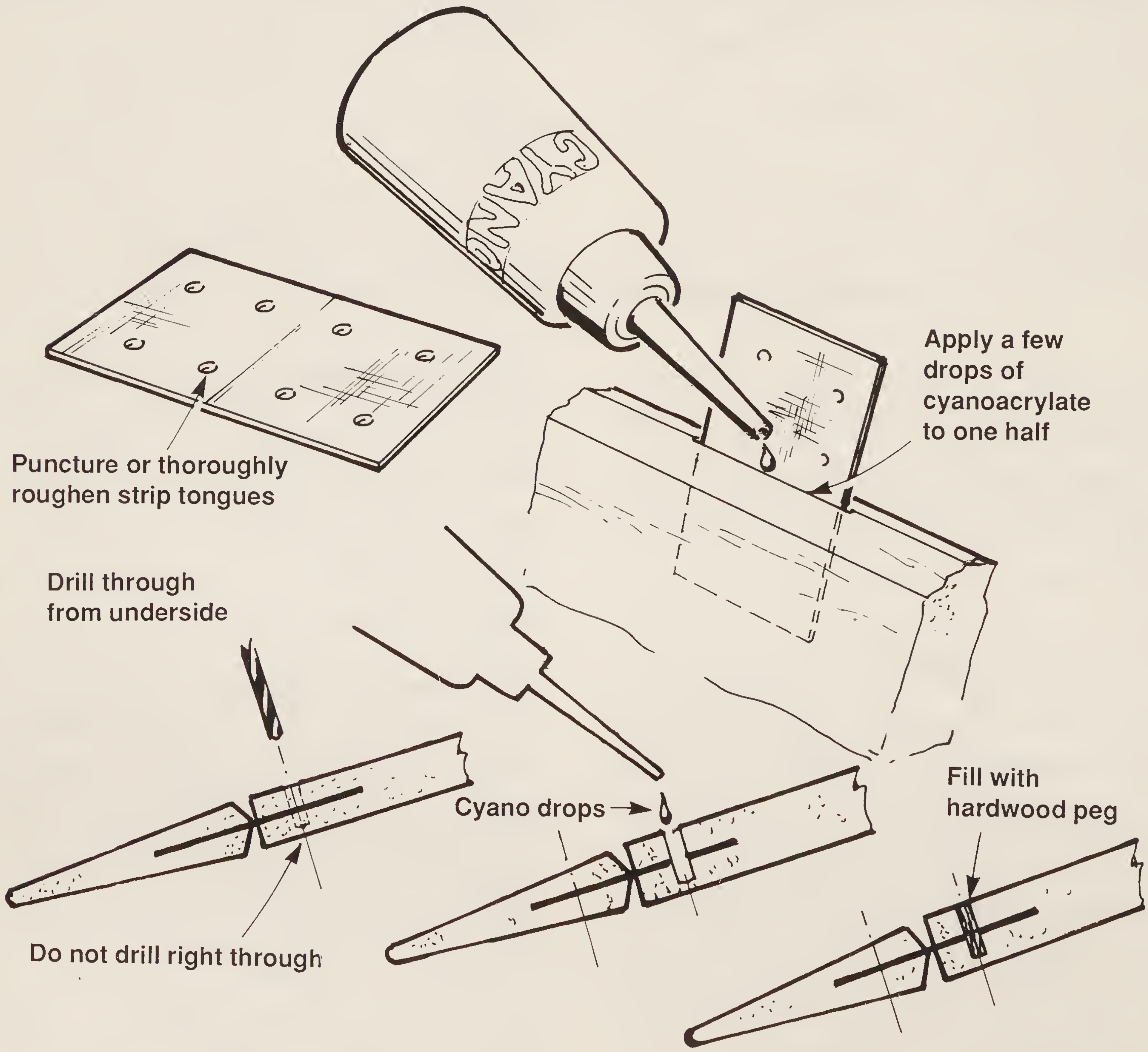


Fig. 1.2 Fixing plastic strip hinges.

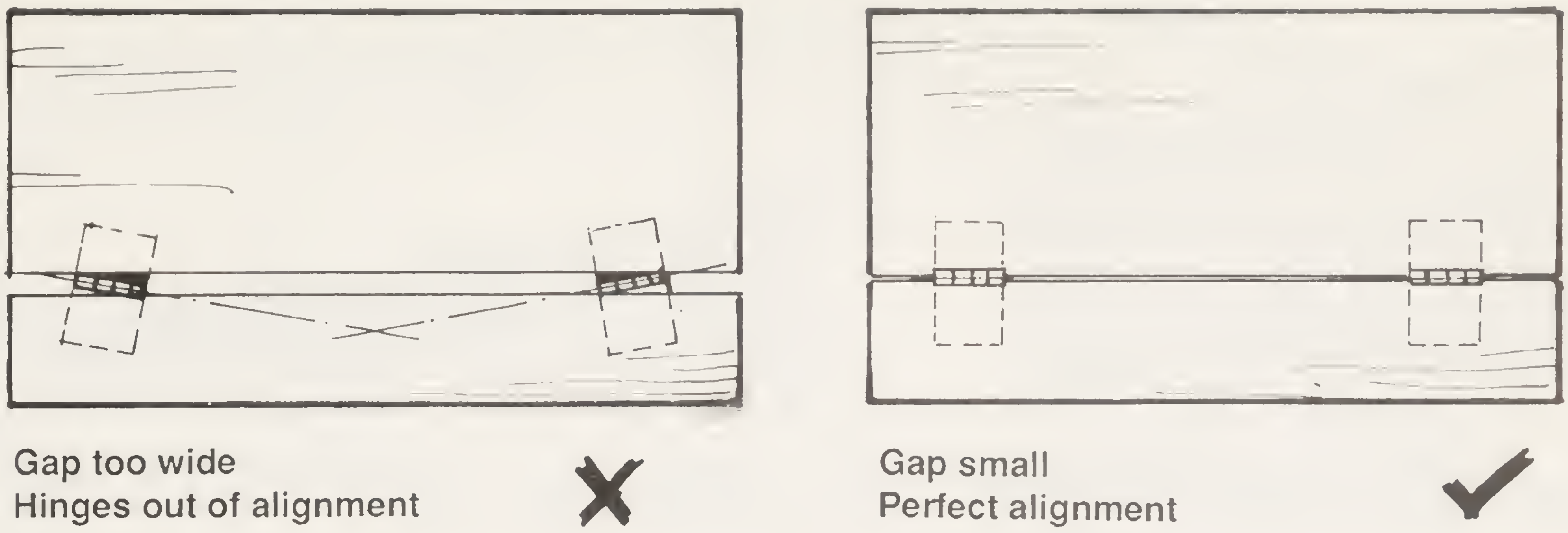


Fig. 1.3 Care in alignment is even more important with pinned pivot hinges.

glue in the hinge pivot is bad news and must be avoided at all costs. Some hinges of this type do not require pinning and with some, because of their shape, pinning is impossible.

Unless care is exercised when fitting pinned pivot hinges, wide gaps between the flying surfaces may result. This is really undesirable as much as aerodynamic efficiency is lost and careful fitting is important, as is careful alignment of the pivot line if stiffness is to be avoided.

Before we leave plastic hinges we should consider how many hinges are required for each application. Obviously, models vary but there are a few basic rules. Even the smallest flying surface requires at least two hinges—one at each end. No control surface should be unsupported for more than 6in (200mm).

If in doubt about the number, fit an extra one. The cost will be minimal and insufficient hingeing can cause control surface flutter and, as already mentioned, that can have disastrous effects.

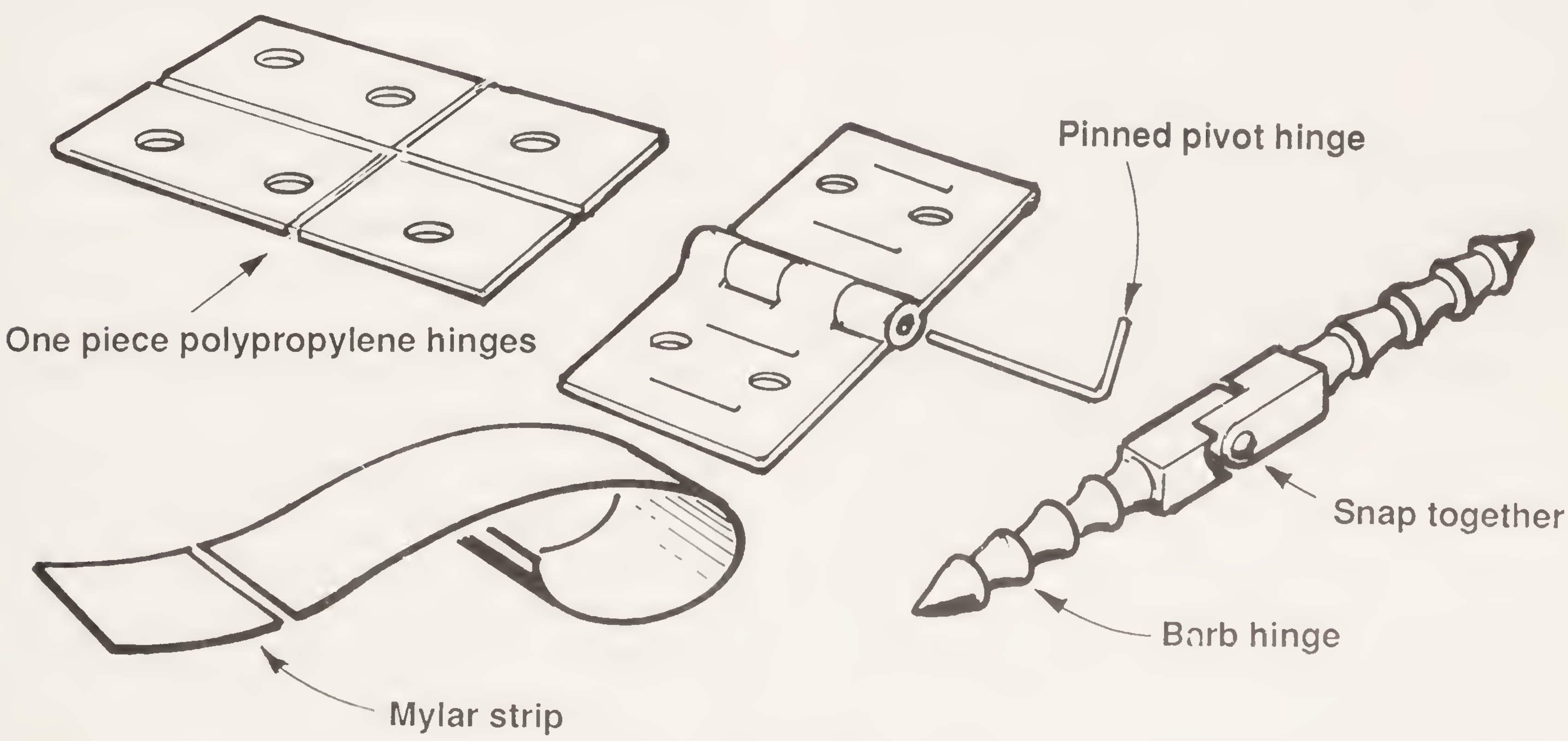


Fig. 1.4 Four main types of hinge. One-piece polypropylene ones can be cut into two or three shorter lengths if required. Easy to fix but must be pinned or pegged. Pivot hinges fit the required criteria exactly if properly fitted and care is taken to avoid glue in the hinge points. Barb hinges require a 3 mm dia. hole 25 mm deep in each component, accurately aligned. Epoxy fills the holes, then the spigots are pushed home; they can be snapped together when set. Cheapest of all is Mylar strip, which gives effective hinges though fractionally stiffer than the pivot type. Remember easy movement, accurate alignment, a small gap and adequate strength are needed with any hinge system.

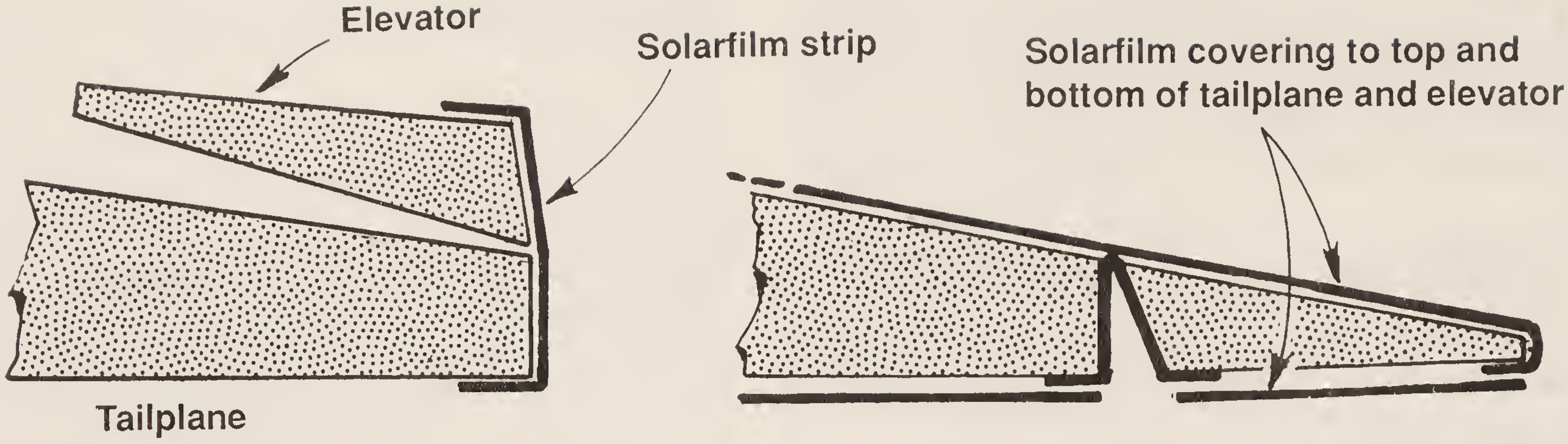


Fig. 1.5 Method of forming a hinge using plastic film covering.

Plastic Film Hinges

Plastic film covering retails under various brand names; Solarfilm, Quickote, Monokote to name but a few. All are suitable for use as hingeing materials providing, of course, that the flying surfaces to be hinged are also covered in the same material.

As the diagram illustrates, when film hinges are used the pivot point is not central but best placed off to one side. This is no problem for horizontal flying surfaces and allows a smooth upper surface. But the method is perhaps best avoided for rudder hingeing where the difference between the port and starboard sides of the model would be very noticeable. Properly applied film hinges are both free and firm and the very design seals the gap between the two surfaces, improving the overall efficiency.

Finally, do remember that, done with care, hingeing is easy and straightforward. However, poorly-fitted hinges can cause control surface flutter and/or radio failure. Stiff hinges drain batteries. Either way the result is the same so check and double check and, if at any stage you are less than happy, do something about it before it's too late.

Chapter 2
Planning your Installation

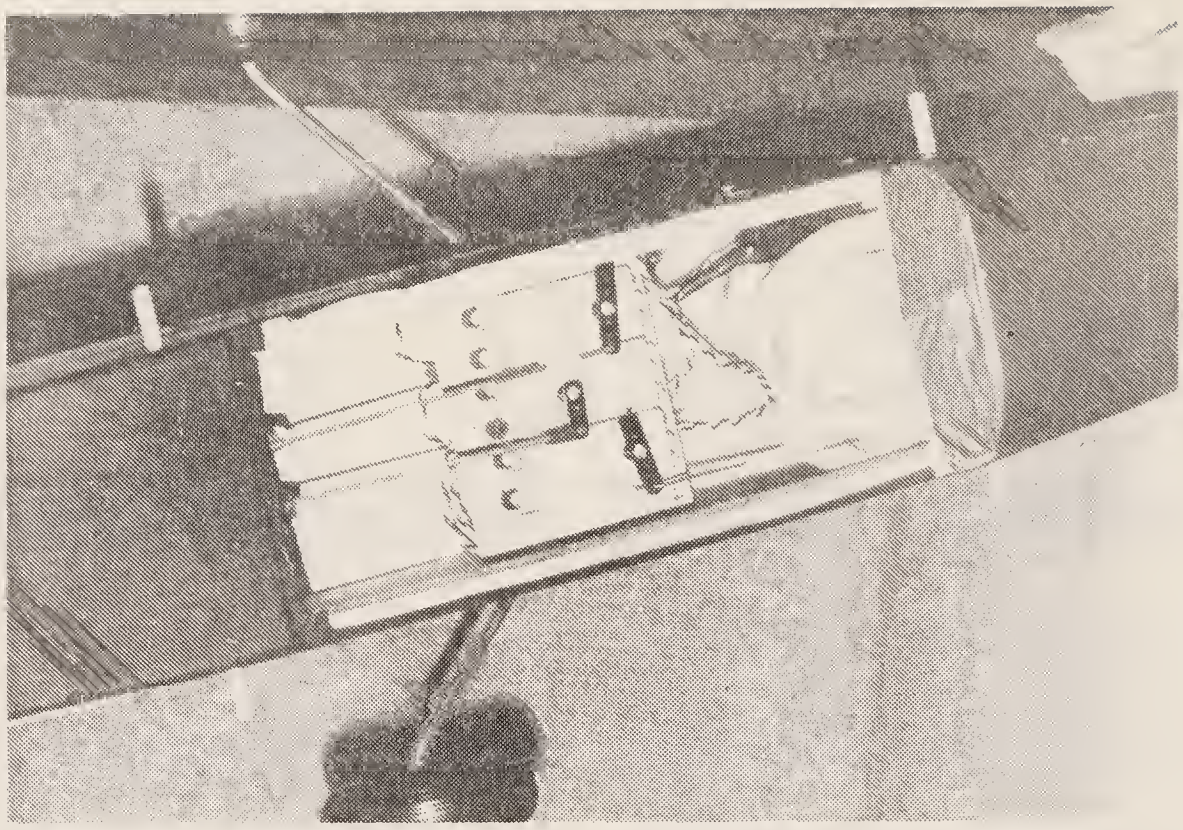
IT IS REASONABLE to regard the radio control equipment as the *heart* of the model. It's also *part* of the model, an integral part, a part which the prudent modeller considers even *before* building commences. Sometimes this consideration is made easy as the kit manufacturer, who has already built and flown the pre-production prototypes, often includes details of suggested radio installation with each kit.

Radio equipment is expensive and a significant investment for the newcomer to the hobby. Not only is it expensive to buy but often expensive to repair, particularly when the repair has been made necessary by impact with the ground. This, of course, is the difference between R/C model aviation and other types of R/C activities. A malfunction in the R/C system of a radio controlled boat will do little more than inconvenience the owner and require the use of a small boat or a pair of waders to effect a recovery. An R/C car going out of control may hit a tree or a post and bend the suspension, but these are small inconveniences compared with the possibilities of an R/C aircraft plummeting from 200ft into the ground. The airframe is almost certainly going to be a write-off and the radio—well, it if did survive and still works it's certainly going to need a checkout by the manufacturer before it can be flown again.

So when installing our sophisticated R/C system we must not only ensure that everything possible has been done to prevent a malfunction but must take steps to protect the airborne equipment in the event of a crash.

Having issued the warnings, let it be said that modern radio control equipment, carefully installed and maintained, is extremely reliable and will, with just a little luck, give long and reliable service. Don't be discouraged by the opening remarks of this chapter, but do be warned and remember that as in full-size aviation, in model aviation "will do" is not good enough.

Radio control equipment adds weight to the model. Every model needs to be kept as light as possible so, when planning our installation it is necessary to use the weight of the radio to help balance the model in the correct position. In so doing we will avoid having to add weight, unnecessary weight, in order to bring the balance point back to the position shown on the plan. As stated earlier, the prudent kit manufacturer or model designer will include



Plan the installation well ahead of fitting the radio equipment. The aileron servo is separately mounted in the wing. Resilient foam should be used for protecting the receiver. The battery is positioned ahead of the receiver, under the fuel tank bay.

details of radio installation, but if by following these the balance point does not come out as shown, repositioning part of the equipment may produce the required result.

The Battery Pack

This is the heaviest item of the airborne radio equipment. It is also the most mobile, not having to be bolted down or left readily accessible, and it is probably the cheapest item in the airborne outfit.

Because of its weight the battery pack is the item which, in a crash, is very likely to create damage. For this reason the battery pack is best positioned forward of the servos and receiver, at the front of the model. Of course, we must not forget the weight considerations discussed earlier, but often the

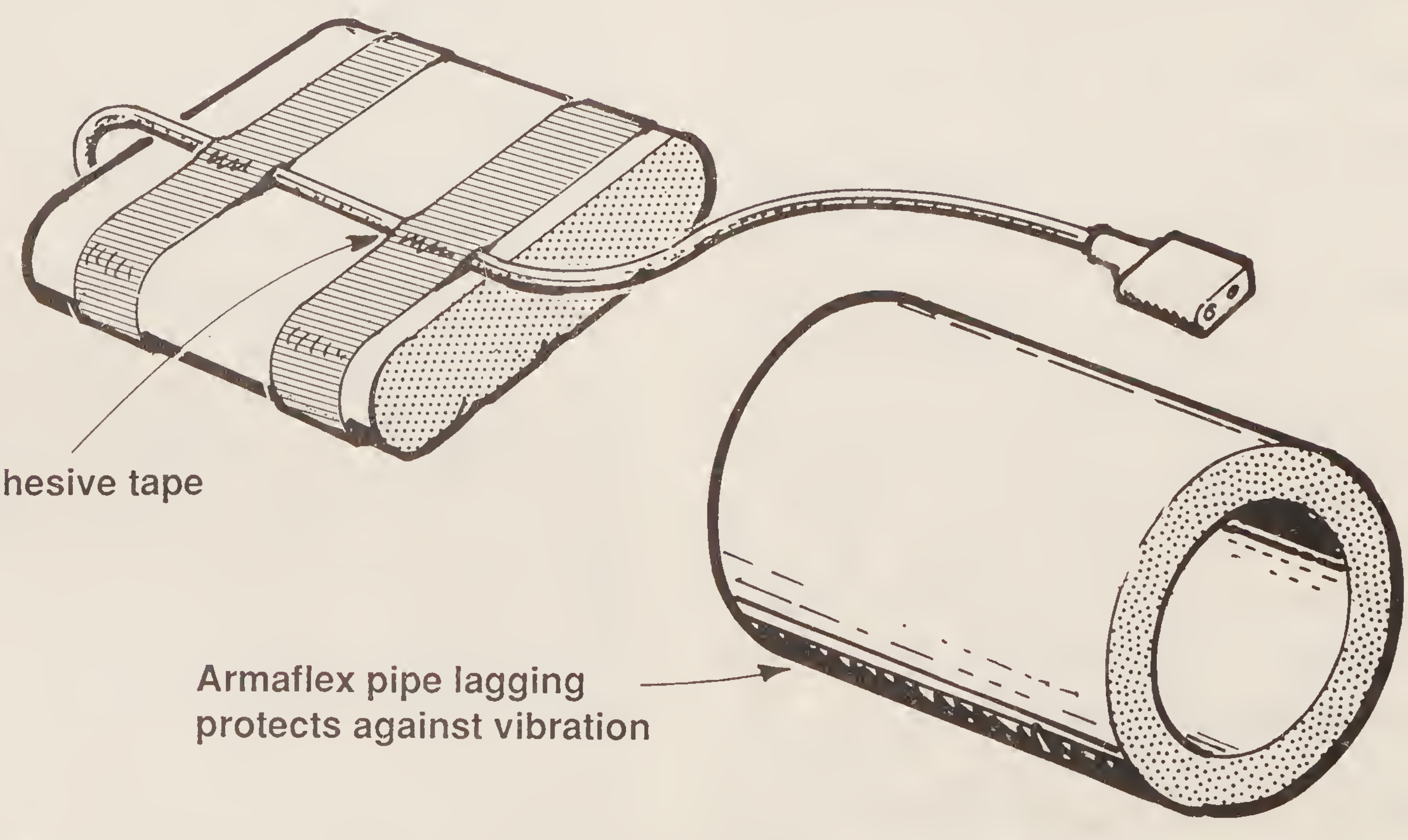


Fig. 2.1 Armaflex protects well against vibration and will minimise damage in a crash.

balance point works out just right with the battery positioned next to, or just behind, the fuel tank.

The battery needs protection, both to reduce the effects of vibration from the engine and protect against damage in a crash. Foam rubber is ideal and a useful source is oddments of carpet underlay from your local carpet shop. Foam rubber may also be obtainable from your local upholstery supplies shop but do avoid *plastic* foam. This is simply not dense enough to absorb the inertia of an impact so, while it will provide some degree of vibration protection, in the event of a crash your battery pack remains unprotected.

A further useful source of protection is obtainable from plumbers' merchants. It's called Armaflex, an elastomeric nitrile rubber foam pipe lagging. This is a strong, dense foam and as it comes in tube form the battery pack can be slipped inside and the ends sealed with scrap. Obtained through the plumbing trade, Armaflex comes in two metre lengths which is far more than you will require for your immediate needs. If sharing the stuff around the rest of the club does not appeal, then Armaflex is available from some model shops in shorter lengths.

When positioning the battery pack take great care not to strain the leadout wires. A broken wire would have disastrous results and a useful precaution is to double back the wire and tape it to the pack as shown in the diagram.

Finally, fuel tanks are quite prone to leaking and even if your tank stays fuel-tight it is quite likely that a leaky fuel line is, at some time, going to spray glow fuel around the inside of the tank compartment. So, if your battery is to reside with the tank, pop it inside a polythene bag after you have wrapped it in foam.

The Receiver

The receiver is not only the most delicate part of your R/C equipment, it is also the most expensive. So, fitting the receiver should be done with extra care, remembering that access is required for frequency changing and, in the absence of an extension lead, for plugging in aileron and other servos.

All too often I have seen the receiver banished to the bowels of the fuselage,

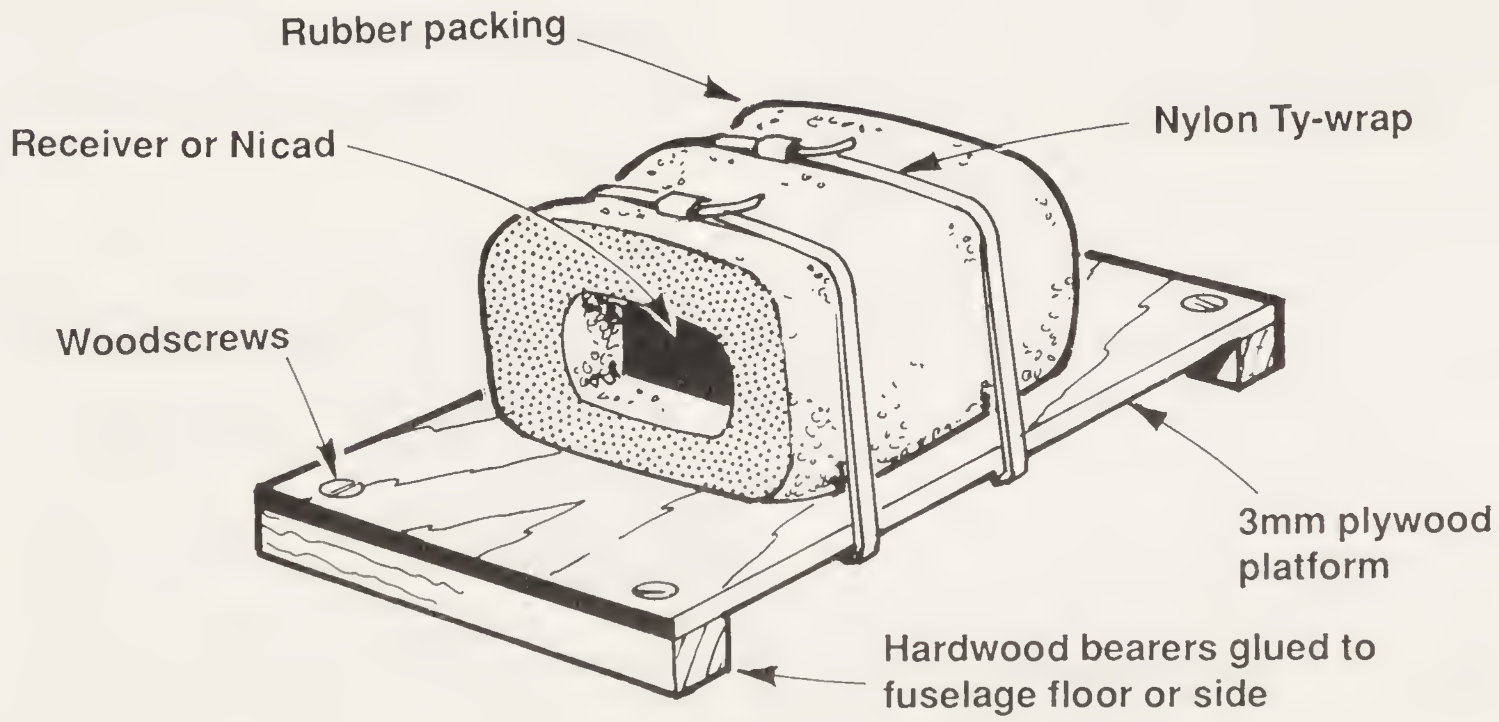


Fig. 2.2 Tie wraps may be used to secure a well-packed receiver or nicad pack to a ply tray. This is a particularly useful method when equipment has to be mounted in a large, cavernous fuselage.

the only evidence of its existence being a rat's nest of wires and leads poking out of a block of tightly wedged plastic foam.

Clearly this is not good and is tantamount to asking for trouble. Our receiver deserves and must receive better treatment. The level and quality of the protection surrounding the receiver should be exactly the same as the battery pack. Sure, it doesn't weigh as much but it costs a lot more, so don't skimp the protection.

Position the receiver so that the output connectors and the crystal holder are accessible. Visualise how the leads to the servos are going to run and how the aerial will be routed from the receiver and along the fuselage. It is not necessary to allow access to the output connectors or crystal with the protection in place and this is where Armaflex tube is extremely useful as access is readily obtainable by simply pushing the Rx out of the tube.

Where the Rx is mounted behind the servos, restraint is required to keep it in place. A simple slide-in lid locating on a couple of bearers glued to the fuselage side will do the trick, the gentle upward pressure of the receiver protection being sufficient to keep the lid in place. Where voluminous fuselages leave the receiver rattling around "like a pea in a drum", surplus space can be usefully filled by extra packing. Polystyrene foam is helpful here as it has useful impact absorbing qualities.

It is, however, pretty useless at absorbing vibrations of the frequency to which our receiver will be subject, so polystyrene foam is only useful as a space-filling secondary packing and not as a substitute for the primary protection described earlier.

The routeing of the receiver aerial needs special attention if the performance of the radio link is not to suffer. First and foremost IT MUST NEVER BE SHORTENED, LEFT COILED OR LOOPED BACK ON ITSELF. Any of these actions will result in an immediate degrading of the performance.

Ideally the aerial should be run outside the fuselage as shown. This is fine for sports and semi-scale models but is unpopular with scale enthusiasts, as it obviously detracts from the appearance of the model. The alternative is therefore to run the wire down the inside of the fuselage. This is perfectly acceptable providing that the connections between the servos and the rudder and elevator surfaces are non-metallic and the finishing material too does not have a metallic content. I'm thinking now of 'metallic' paints and covering materials which actually consist of metal particles. Such finishes can have

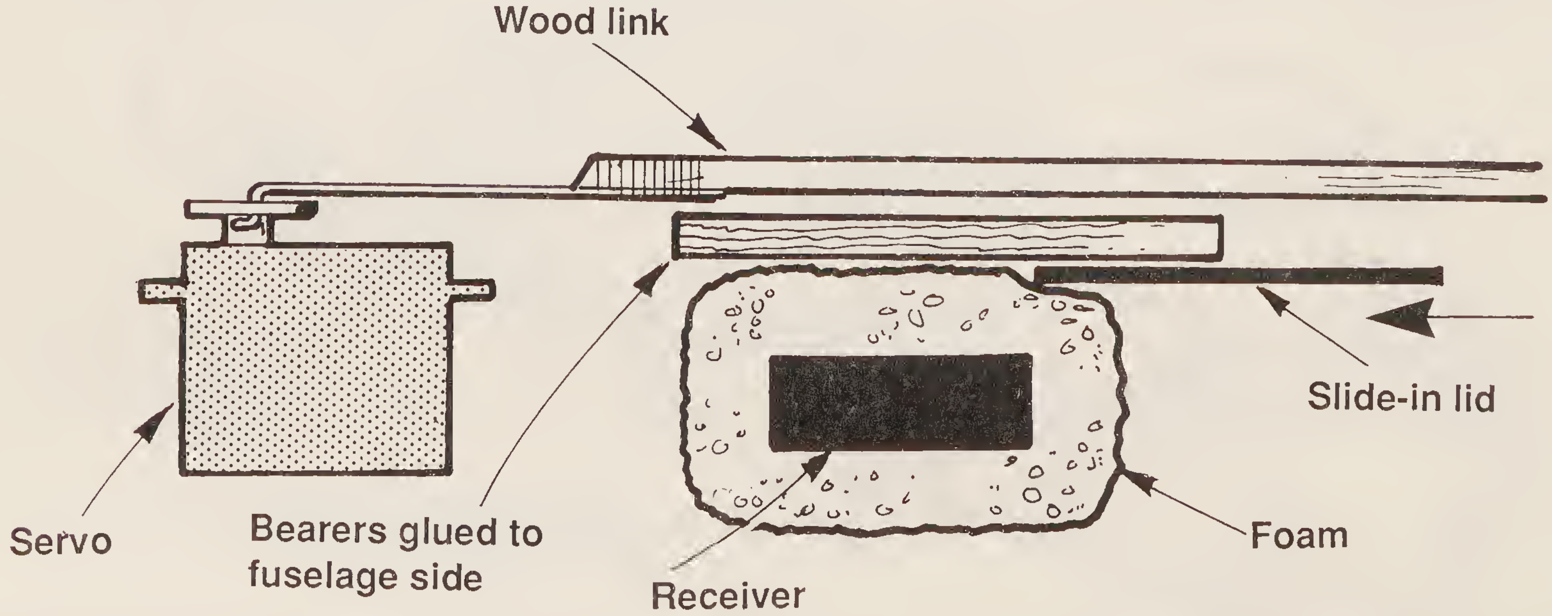


Fig. 2.3 Where the receiver is behind/below the servos, a sliding lid prevents it from moving.

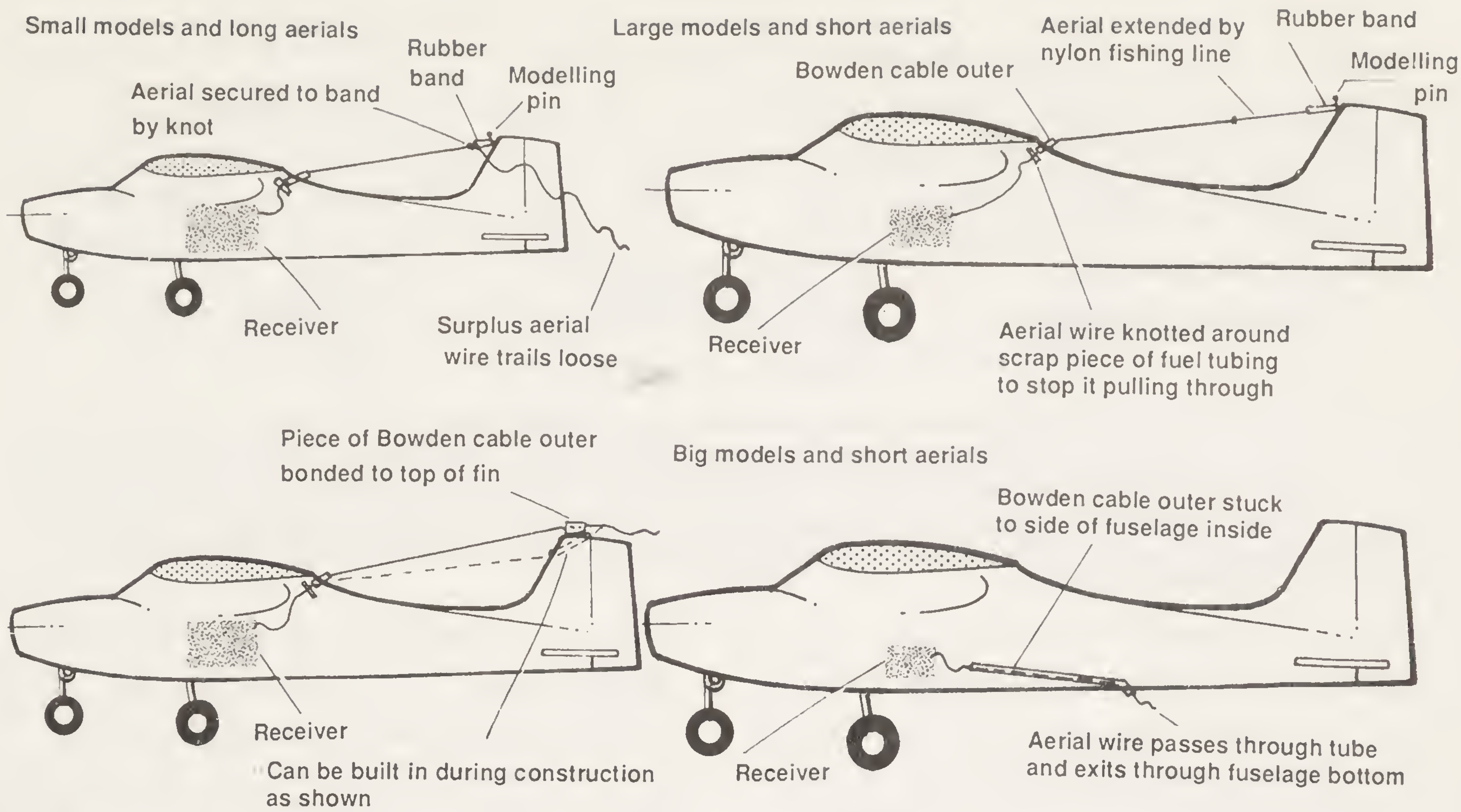


Fig. 2.4 Methods of mounting aerials.

a screening effect and should be used only with great caution.

If the fore-aft control runs are to be metallic, i.e. Bowden cable or closed-loop, it doesn't necessarily mean that an internal aerial is not possible. However, the closer the receiver aerial is run parallel to another metallic object, the more likely radio problems are. Unfortunately there is no hard-and-fast rule, so proceed with caution. With modern FM radio it is unlikely that any problems that did occur would result in complete radio failure but any apparent glitches should be taken as a warning that all is not well.

Finally, we must not forget that the fuselage is not the only suitable location for mounting a Rx aerial. The wing, if it is of large enough span and not covered in metallic material, is an ideal place to house the aerial. Provision must be made at the building stage by fitting a plastic tube (Bowden cable plastic outer is ideal) along the span. Of course it is then necessary to feed the aerial wire along the tube every time the wing is positioned but this is no real problem and adds only seconds to the time spent assembling the model.

Servos

The R/C industry offers its customers an amazing choice of servos for a vast range of applications, from the micro-servos for ultra-lightweight models to the beefy but slow servos designed for heavyweight applications, such as retracting undercarriages.

Servos are the interface between the electronic and mechanical control systems. They are tough and reliable but do need careful handling. They must also be positively mounted, otherwise all the accuracy built into the servo by the manufacturer will be lost if the servo is able to move on its mount.

Servos are sometimes offered with a choice of rotational directions. This simply means that for the same given command one servo may rotate in one direction while its counterpart with an opposite rotational direction will rotate in the other. If servo reversing at the

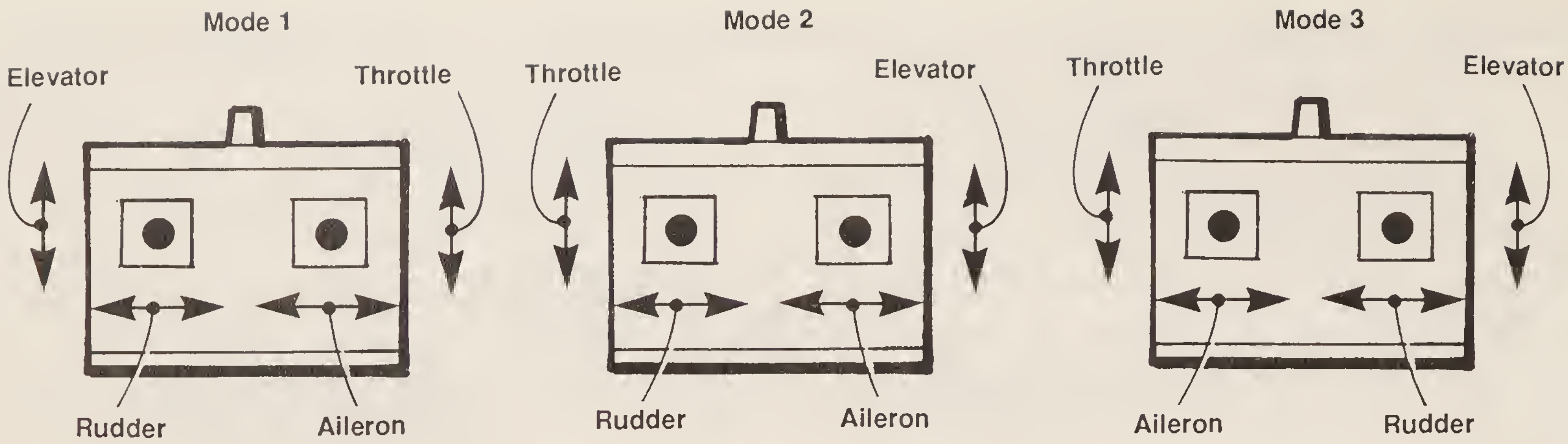


Fig. 2.5 Modern R/C systems usually adopt one of three transmitter layouts or "modes". It is generally accepted, though often fiercely debated, that there is no best mode. The only criterion is that the mode chosen by a beginner is the same as that used by the expert who is going to teach him to fly. Note that while left-right functions are self-explanatory, up elevator is arranged with the elevator stick towards the base of the Tx and full throttle with the throttle stick towards the Tx case top. These are in fact "naturally sensed" and correspond to full-size usage.

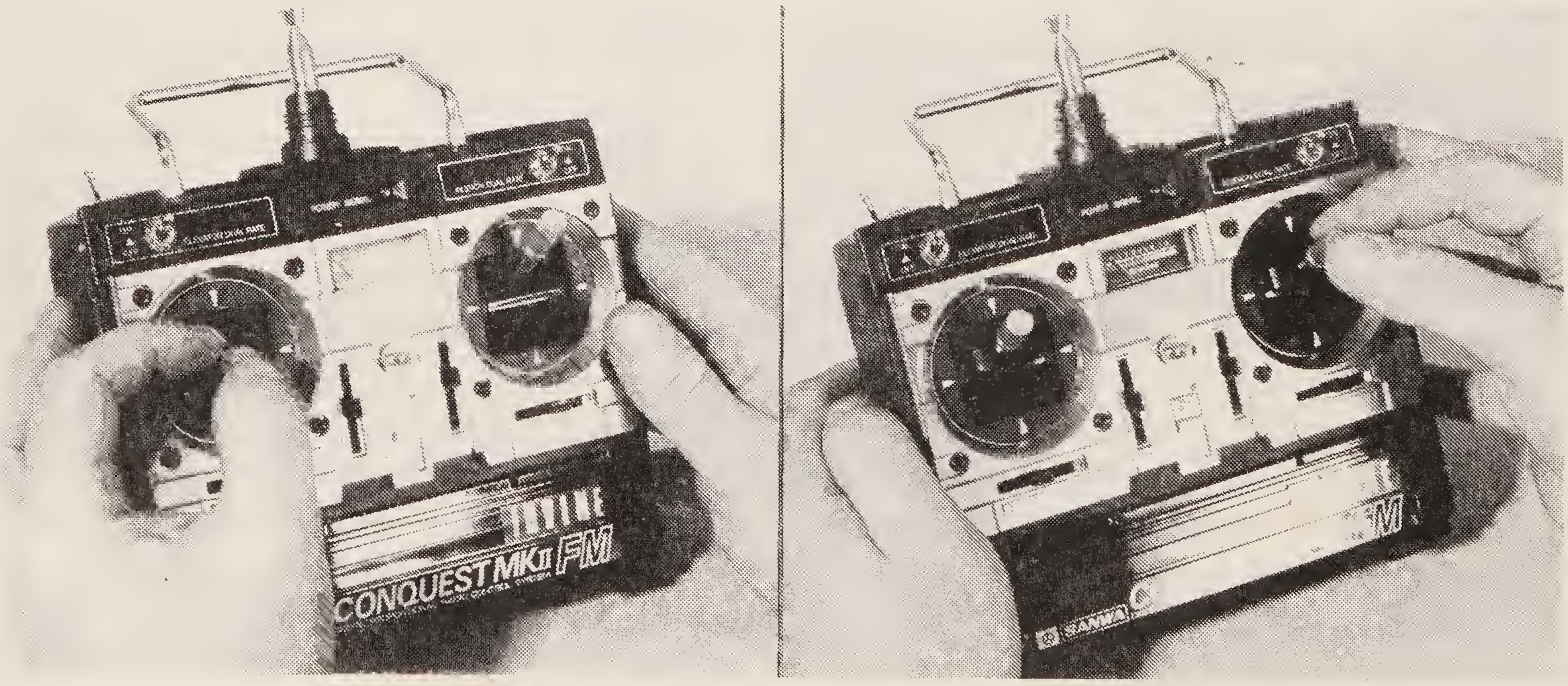
transmitter is available then this need not worry us, but if not, then care is required to ensure that, on completion of the installation, all the controls move in the correct sense.

Servo Mounting—Bearers

The popular and simple way of mounting servos in a fuselage is by using hard-wood bearers. These should be fixed accurately across the fuselage and glued in place using balsa reinforcing patches. Accurate spacing is important. No part of the servo should touch the bearer, the only contact being via the grommets. Spacing the servos along the bearers, too, is important as adequate space has to be allowed for pushrod attachments to the output arms. In fact, it's far better to leave the actual spacing of the servos until the control linkages have been provided.

Servo Mounting—Trays

Time spent making a servo tray can save the builder many hours of labour at a later date. This is particularly true when it is intended that the radio will be transferred from model to model on a regular basis. What better than to have one universal tray which, by releasing four screws, allows three servos plus



The same basic Tx is here shown in Mode 1 (left) and Mode 2 form. Mode 3 is less common.

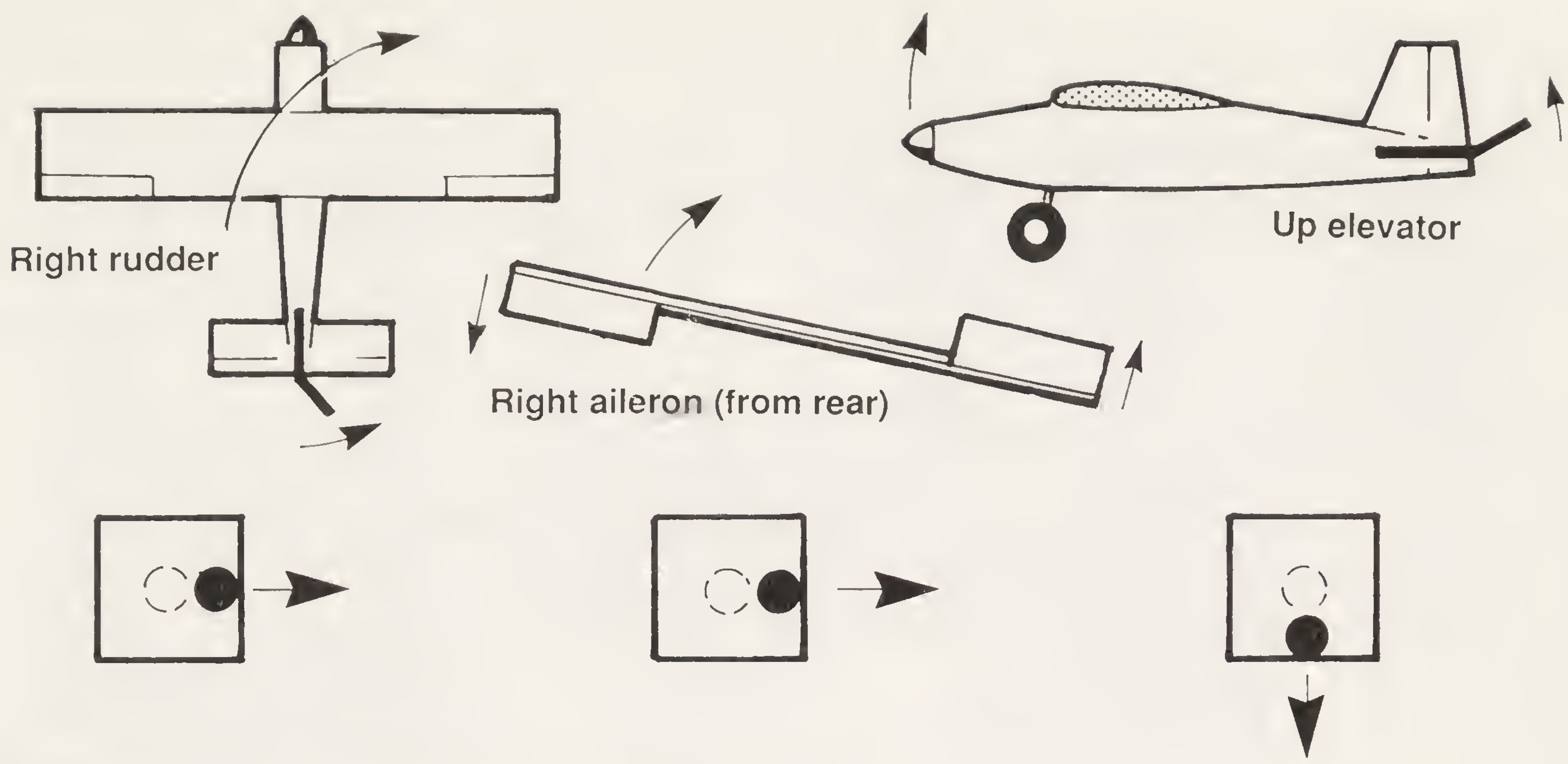


Fig. 2.6 Ensure that all controls move in the correct sense.

the switch to be transferred to another model?

A rigid but light tray can easily be made by bonding 1/16in ply to 3/16in balsa using contact adhesive.

The use of servo trays allows a choice in the method we use for securing the servo to the tray. Screws and grommets are, of course, the traditional method; providing the screws are not over-tightened and no part of the servo can touch the tray, this method is safe and secure.

Double-sided foam tape is available

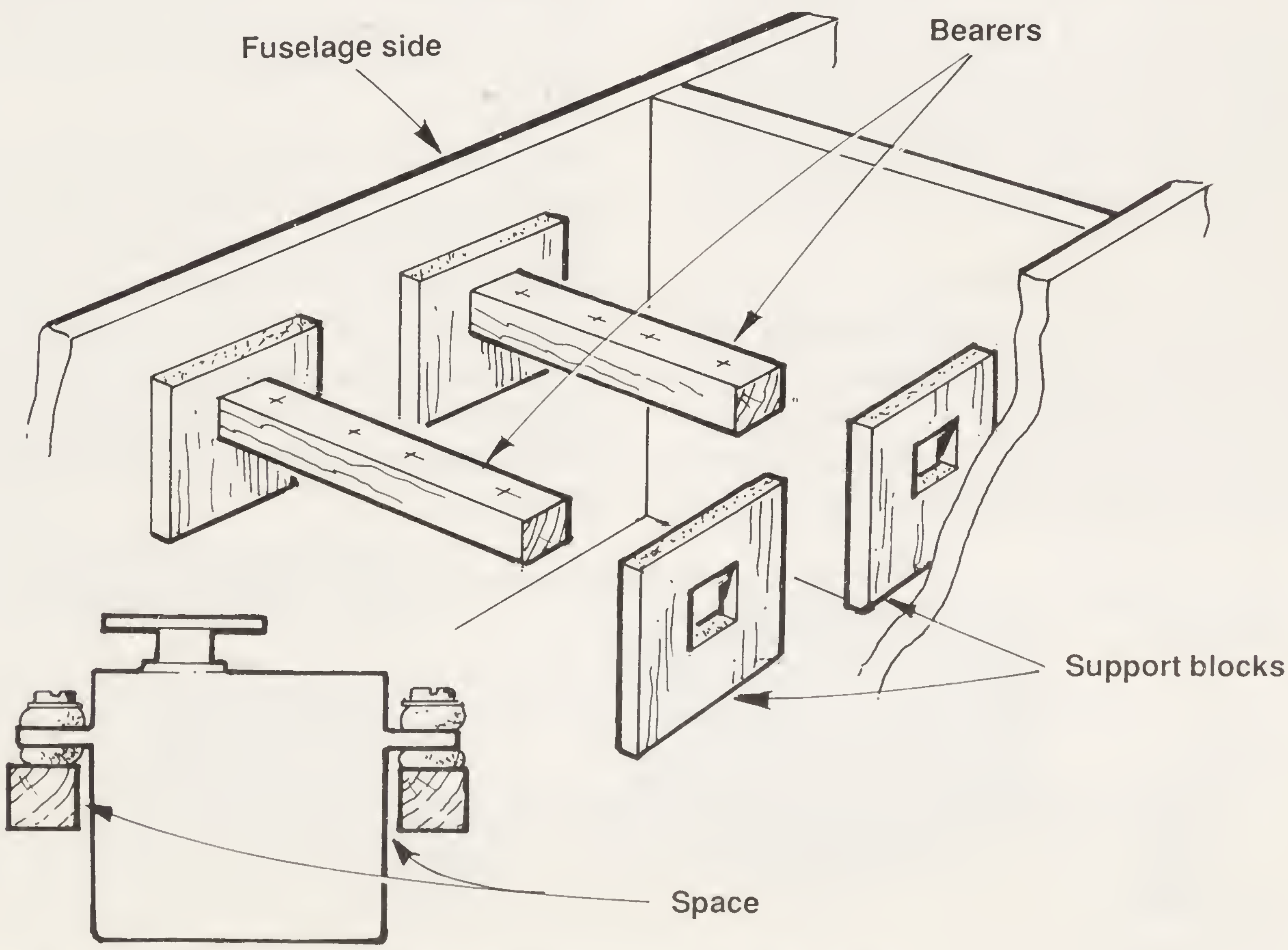


Fig. 2.7 Servo mounting on bearers is probably the commonest practice.

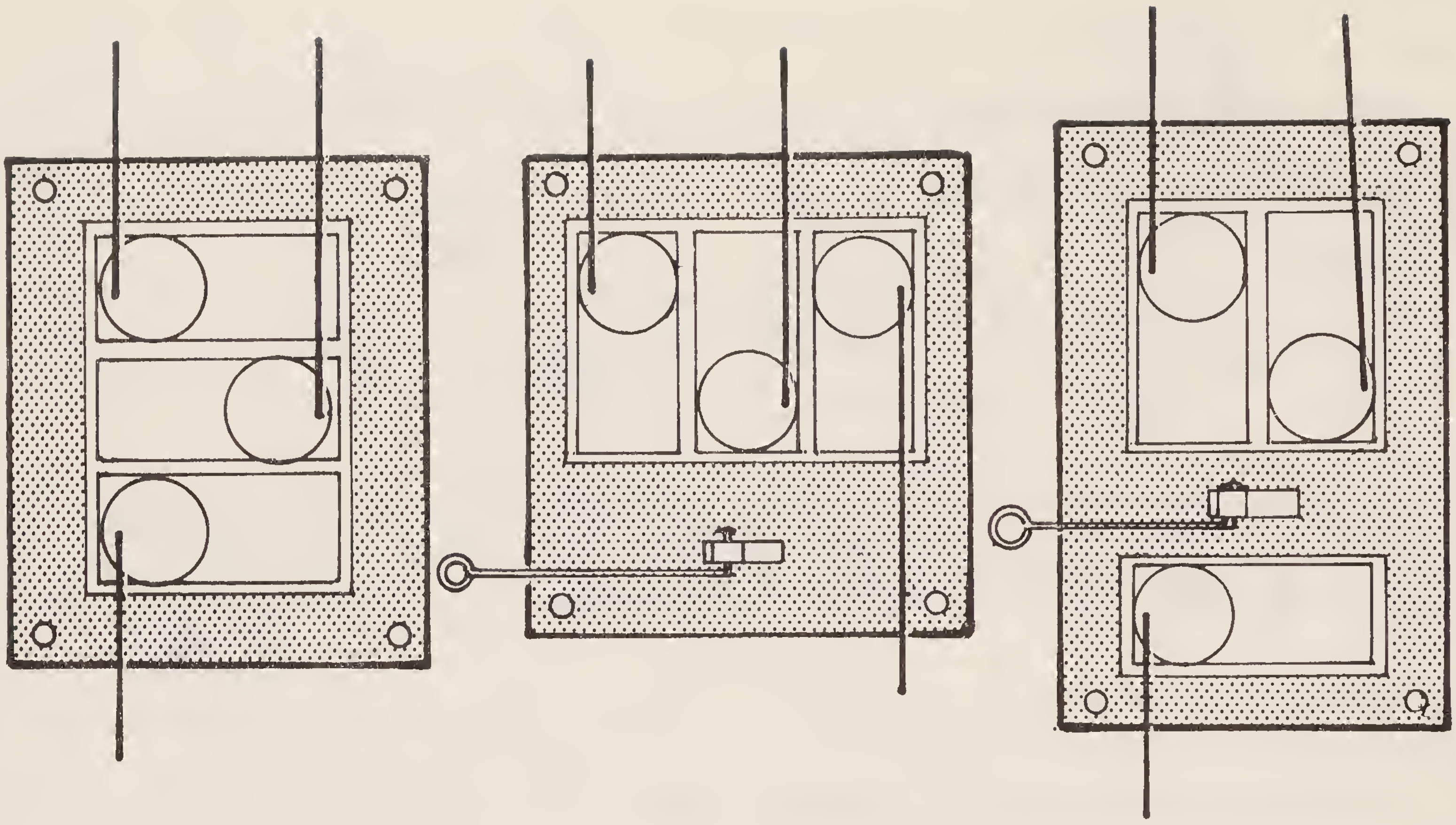


Fig. 2.8 Servo trays offer different layouts and are easily transferable.

for servo mounting and while I would hesitate to recommend it for large model applications I have used it on smaller models with success. The tape is used to stick the servo to a suitable tray. But there are pitfalls. The surface of the tray must be smooth and sealed. The servo and the tray must be clean and free from dust, dirt and grease. Then, and only then, is an adequate bond likely.

However, a word of caution. A couple of years ago, in the middle of a heat wave, I left two models standing on their noses in the corner of the workshop. After just one day in the sun I found that the heat and the weight of the servo acting constantly on the adhesive had 'peeled' back all four servos and they were hanging by the pushrods.

I quickly modified the trays and secured the servo to the tape with a rubber band, a belt and braces approach which has to date prevented any recurrence.

Whatever method of servo mounting you decide to use it's worthwhile to keep a record of servo layout for future use. A diagram left inside the model when the equipment is removed is best. Servos can be marked to indicate direction of rotation and receiver output connectors, if numbered, can be labelled with the function.

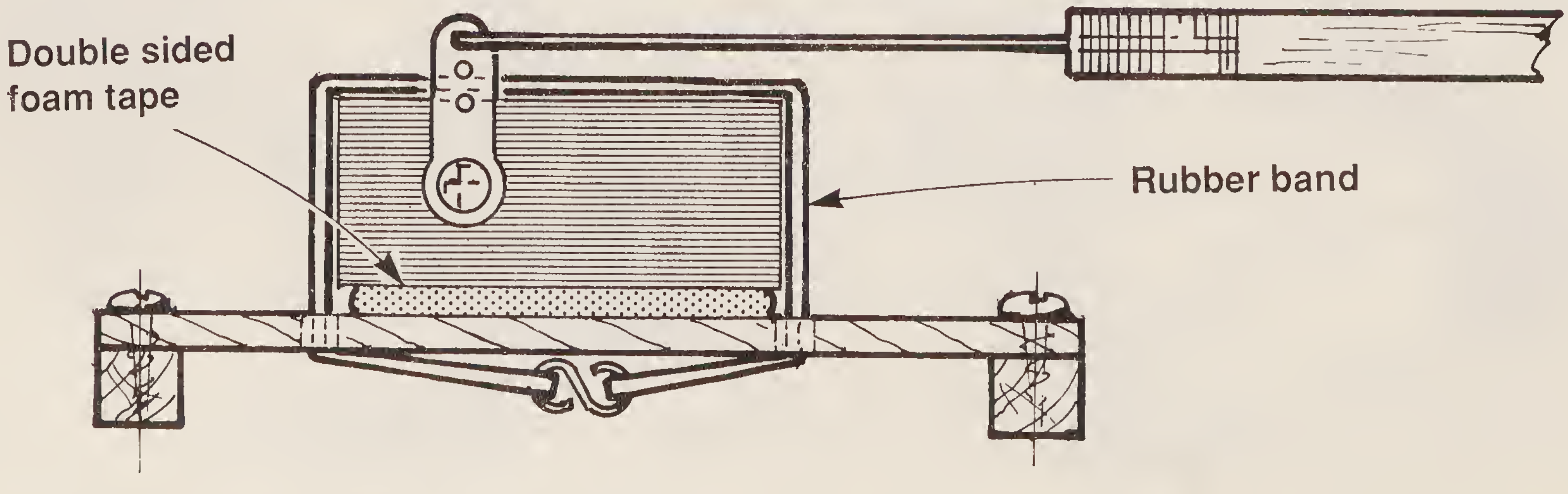


Fig. 2.9 Tape and a rubber band provide a reasonably secure mounting.

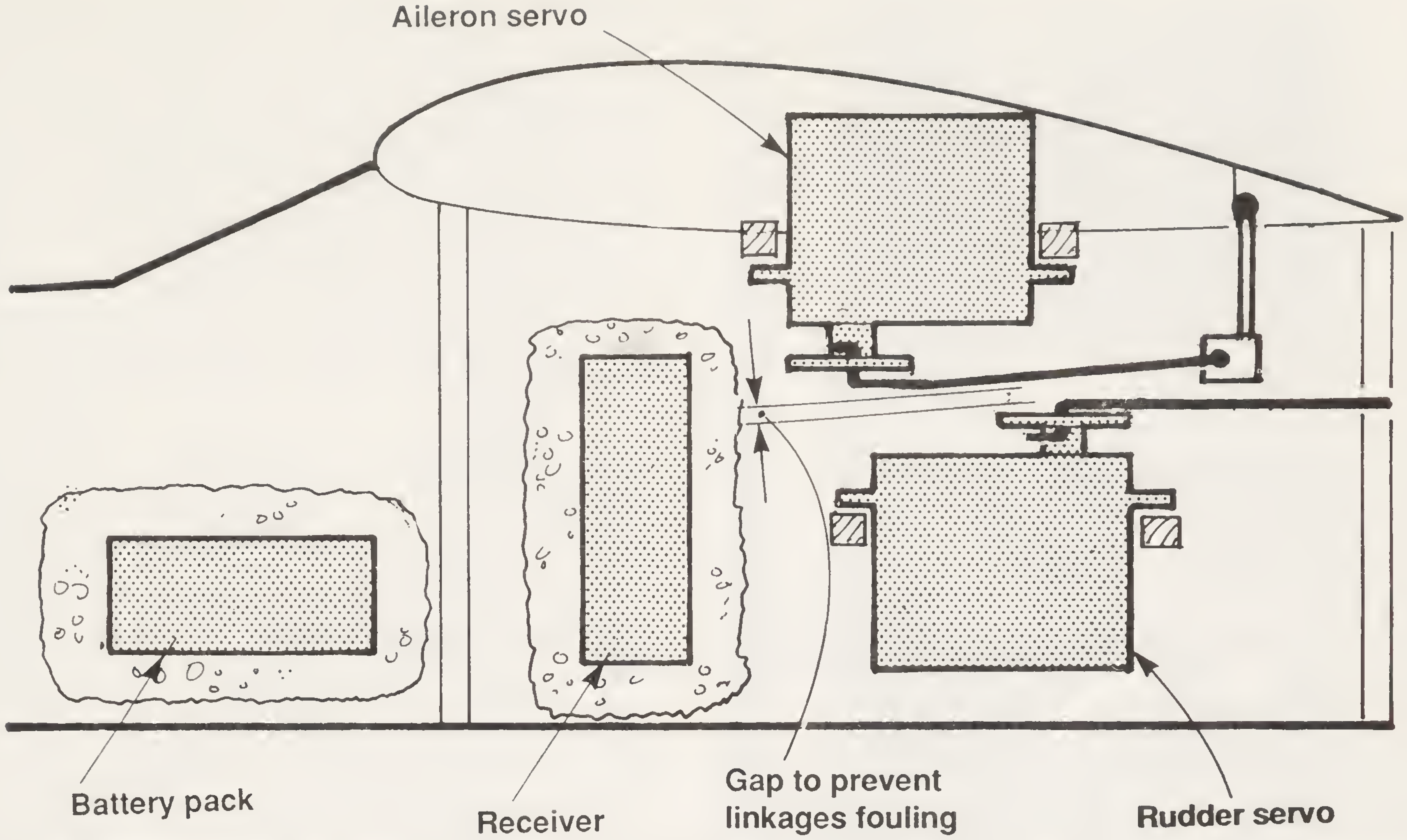


Fig. 2.10 Ensure that aileron servos cannot foul linkages for other servos when the model is assembled.

Aileron Servos

Further information on aileron servo installation is included in the linkages and pushrods chapter. However, the aileron servo must be considered at the time the fuselage installation is undertaken. The aileron servo normally sits half in, half out of a 'purpose-made' box in the wing. Linkages vary according to the type of aileron fitted but in all cases some intrusion into the fuselage cavity is unavoidable. This need not be a problem providing adequate allowance is made and sufficient room left above (or below) the servos and receiver in the fuselage.

Servo mounting in the wing is easy. Providing the sides and base of our purpose-made box are sealed, servo tape used on the base *and* side of the servo is ideal.

Where the servo is required to be vertically mounted, small ply plates can be provided in the box and screws and grommets used to secure the servo.

On/Off Switch

Small, simple and insignificant? Maybe, but consider the implications if suddenly the on/off switch stops working. Correct mounting is vital. The majority of on/off

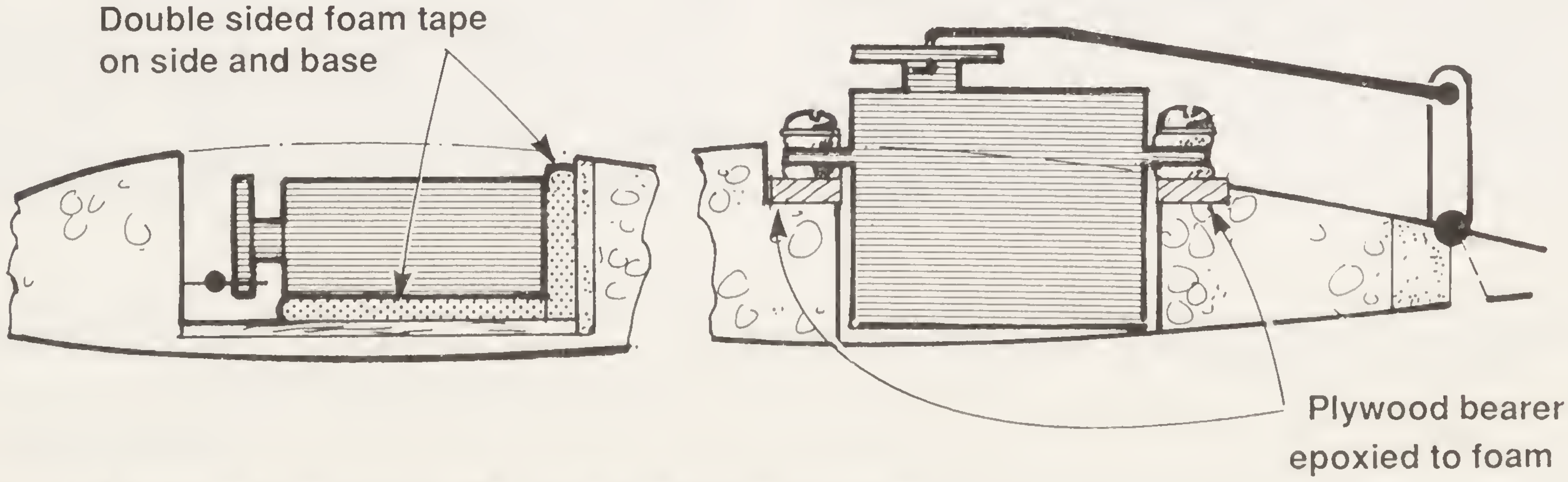
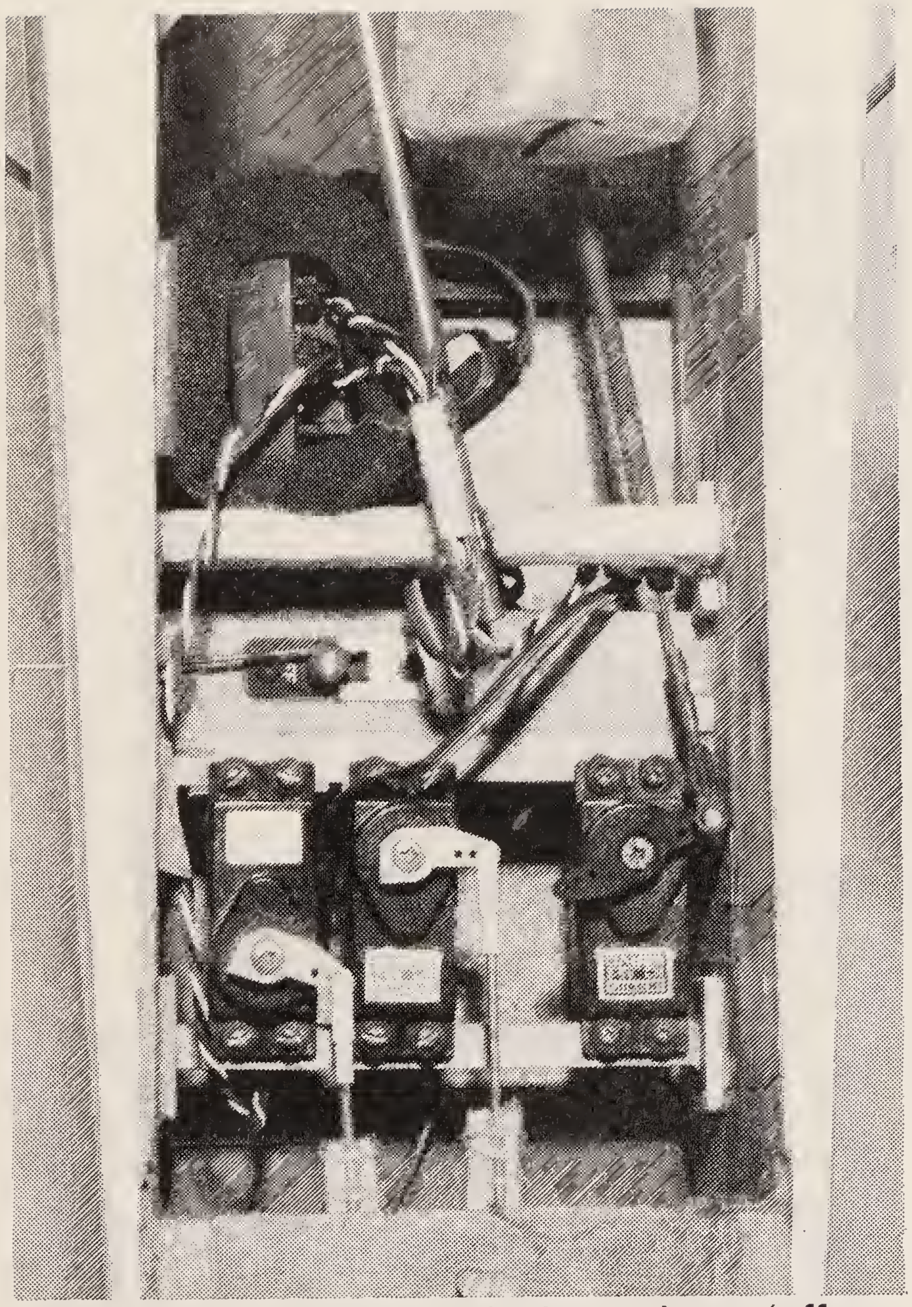


Fig. 2.11 Methods of mounting aileron servos in foam wings.



Installation in this *Magnatilla* shows the on/off switch (centre left) and, from top, battery and back end of fuel tank, receiver and (bottom) servos. Note throttle push-rod.

switches supplied with today's modern radios are of the type illustrated. Put simply this means that operating the switch 'changes over' from one set of contacts to another. With the switch in the OFF position the battery is connected via the switch to the charging lead. Switching to the ON position disconnects the charging lead and connects the battery to the Rx connection.

As two sets of contacts are available the switch is wired with the contacts in parallel to provide an extra safety factor.

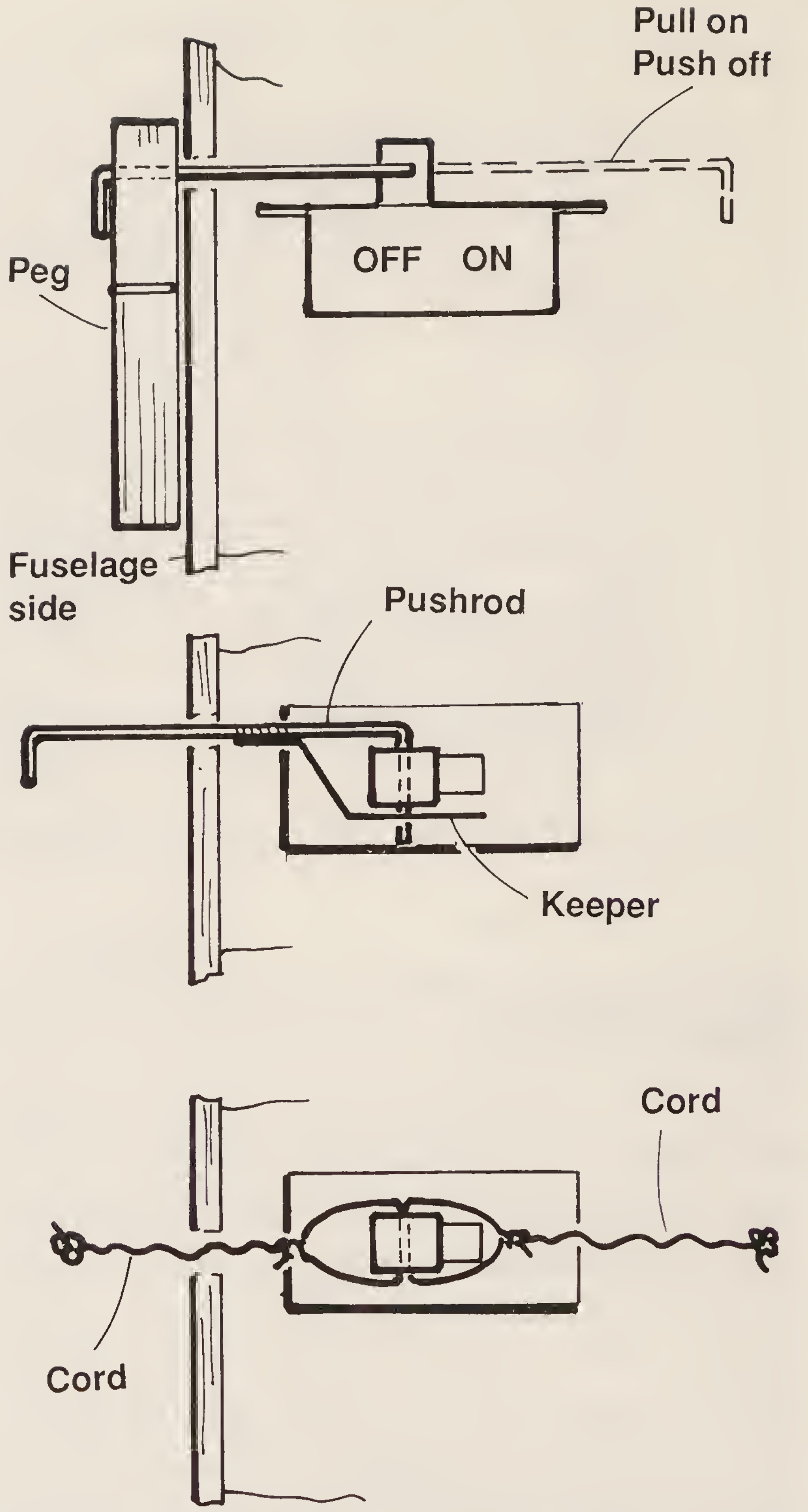


Fig. 2.12 Switch operation from outside of model.

Nevertheless, switches are mechanical devices working in a high vibration environment under high G loadings. As such they are weak links and potential sources of failure. Great care must be taken with siting and mounting.

The 'popular' position for the switch is on the fuselage side. If this position is chosen then the switch must be mounted ON THE OPPOSITE SIDE OF

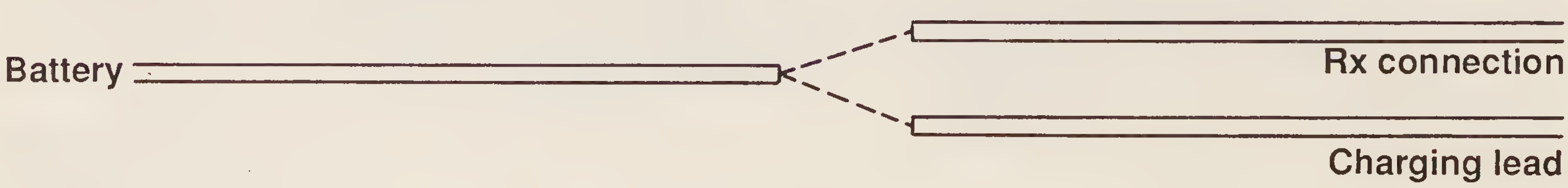


Fig. 2.13 Change-over of connections with a conventional modern R/C on/off switch.

THE FUSELAGE TO AND WELL AWAY FROM THE ENGINE EXHAUST OUTLET. Oil and dirt just don't mix with electrical contacts. The ingress of oil and dirt is not the only problem associated with an externally mounted switch: it's unsightly, particularly on a scale model, and likely, unless carefully positioned, to be knocked off during frantic hand launching.

Internal mounting provides the answers, particularly if provision is made for the switch on the servo tray. A tiny hole drilled through the switch will accept a piano wire connection and the builder has a choice of push on or push off, depending of course on which side of the switch he connects to. My preference has always been for the pull-on method, as this makes accidental switching on less likely. Where the push-on alternative is favoured consider using a peg as shown to prevent accidental switching on. It's infuriating indeed to arrive at the field on a glorious flying day only to find the switch was knocked on while loading the car and the batteries are flat.

Generally switches are not oversensitive to vibration and resilient mounting is not essential. However, avoid areas of high vibrations, particularly close to engines. Another possible region of vibration is the flat sides of plastic or glass fibre fuselages. The plastic, just like the skin on a drum, vibrates in sympathy with the engine. Look at the switch with the engine running at different speeds. If you can see more than one then you've got a serious vibration problem! Siting a switch close

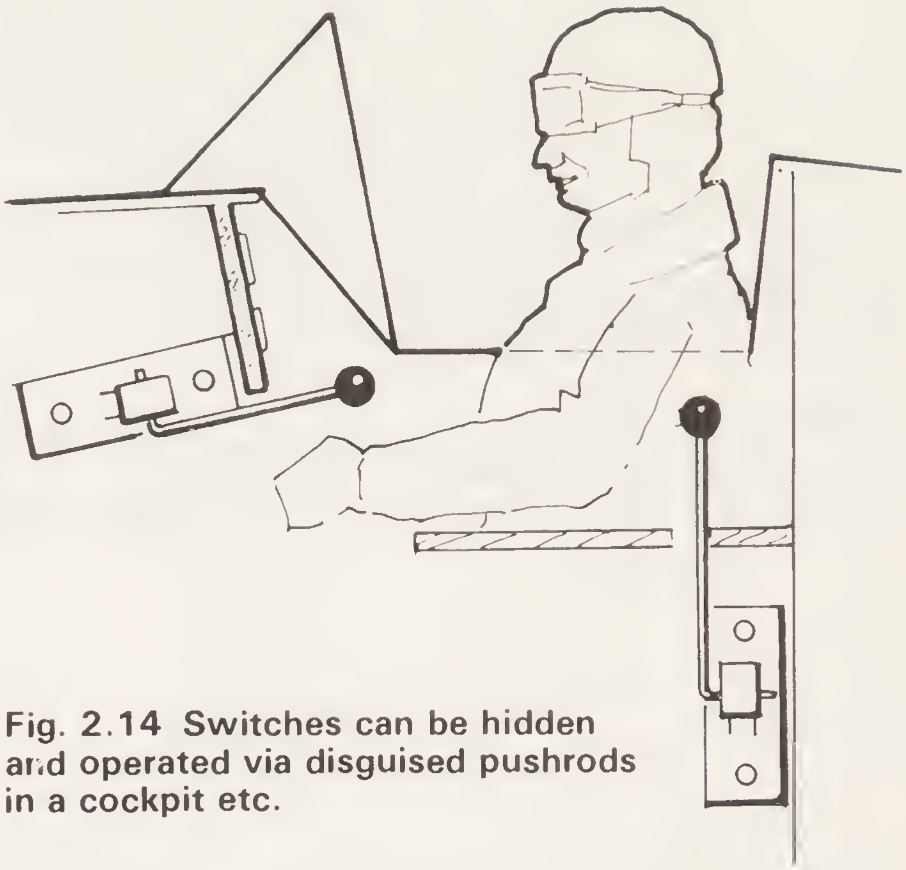


Fig. 2.14 Switches can be hidden and operated via disguised pushrods in a cockpit etc.

to a corner or bulkhead is the answer.

Scale models demand that the switch is hidden. Inside the 'dash' or under the pilot are popular alternatives on open cockpit scale models, again using a wire pushrod to make operation possible. But if a tiny pushrod is used do ensure that it is supported along its length in case it resonates in sympathy with the engine and provides yet another source of potential failure.

Finally, a recent trend amongst some competitive aeromodellers has removed the switch altogether. Where a canopy or hatch is removable to provide immediate access then the switch can be eliminated and the battery pack plugged directly into the receiver before the flight and unplugged on landing. This eliminates one possible source of failure but unless the connecting operation is done with great care, repeated plugging and unplugging may weaken the connectors.

Chapter 3
Connecting Up

A VISIT to a well-stocked model shop or a browse through a manufacturer's catalogue is enough to convince any modeller that the range of links and fittings for R/C use is indeed vast and sometimes confusing. What are they for? What do they do? In this chapter we begin by reviewing the available fittings and then describe them again in practical applications.

Control Horns

These are the levers, normally attached at right-angles to the control surfaces, which convert the fore-aft travel of the pushrod or cable into control surface movement. They are available in a variety of designs but essentially all do the same job.

'Bolt on' Nylon Horns

These bolt through the flying surface. Where the surface is of a soft material or quite large the provision of a thin plywood plate set into the balsa surface to spread the load is a wise move.

It is desirable to arrange the horn so that the connection point to the pushrod is at 90 degrees to the centre line of the control surface and in line with the hinge line. This will avoid undesirable differential, i.e. the control surface moves more in one direction than the other for a given pushrod movement.

Differential Horns

The differential mentioned above is not always undesirable. Indeed in some

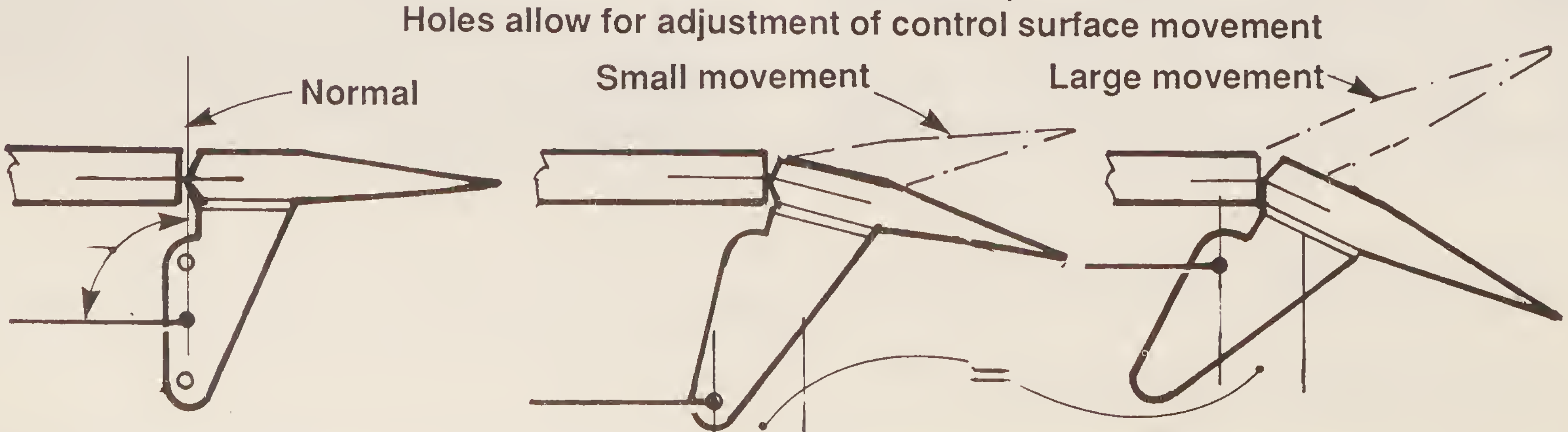


Fig. 3.1 Adjusting degree of movement. These are bolt-on horns moulded with a base flange.

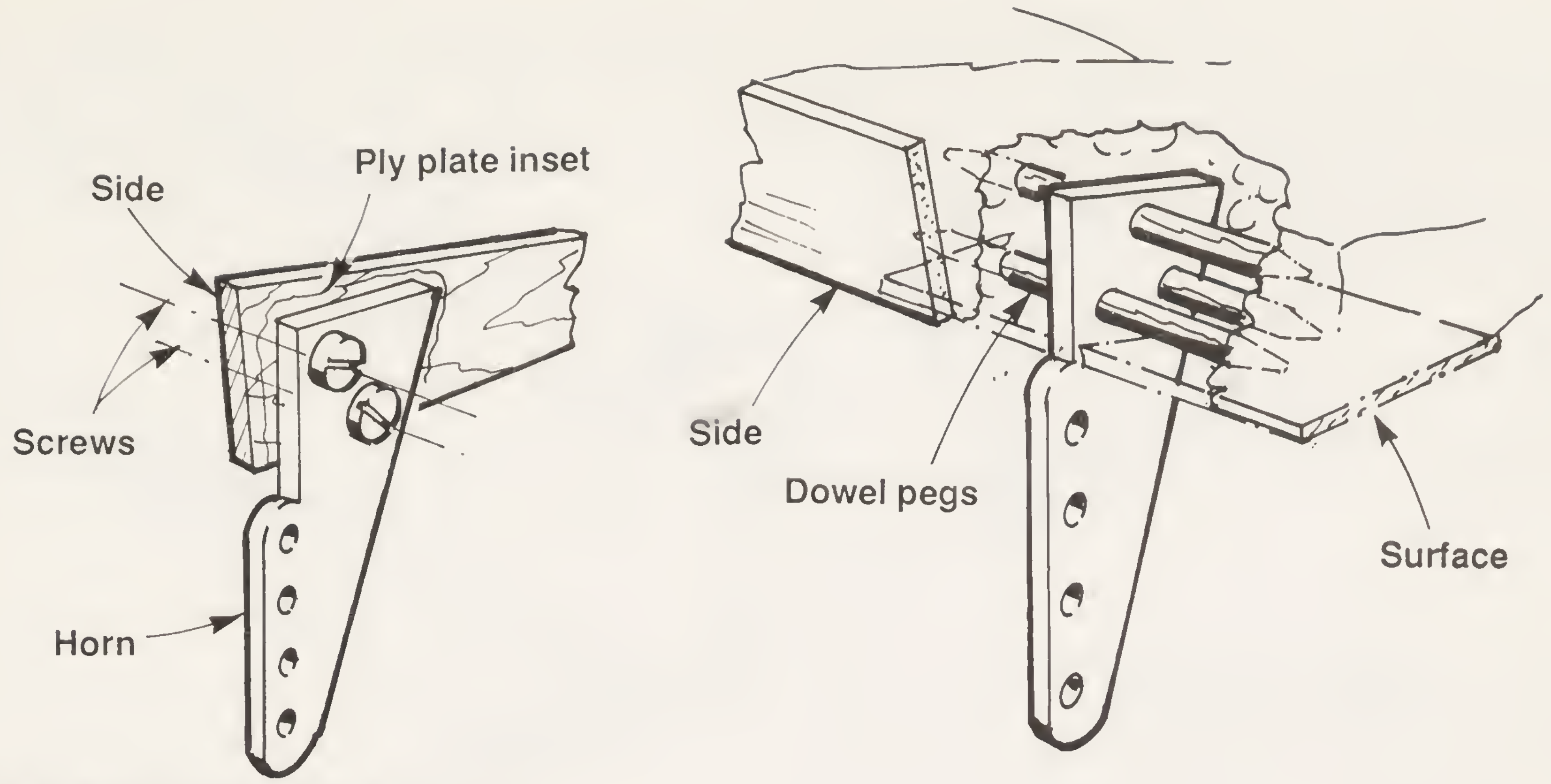


Fig. 3.2 Build-in type horns.

models, for example high wing scale models such as the Piper Cub, it is quite necessary. The sharp rake of the differential horn automatically provides the desired effect. (More about this later.)

Build-in Horns

Moulded without a 'base', these flat plate horns are designed for hidden fixing. Using the holes provided, they may be bolted to a control surface rib during construction or glued in, the holes providing a good keying for the adhesive. Where this type of horn is used on an aileron constructed from polystyrene foam it is again necessary to provide a plywood plate to spread the load. A fourth wise precaution is the provision of short lengths of 1/16 dowel (cocktail sticks or matchwood) under the surface, again to spread the load. You can easily make this type of horn from thin Paxolin or Formica.

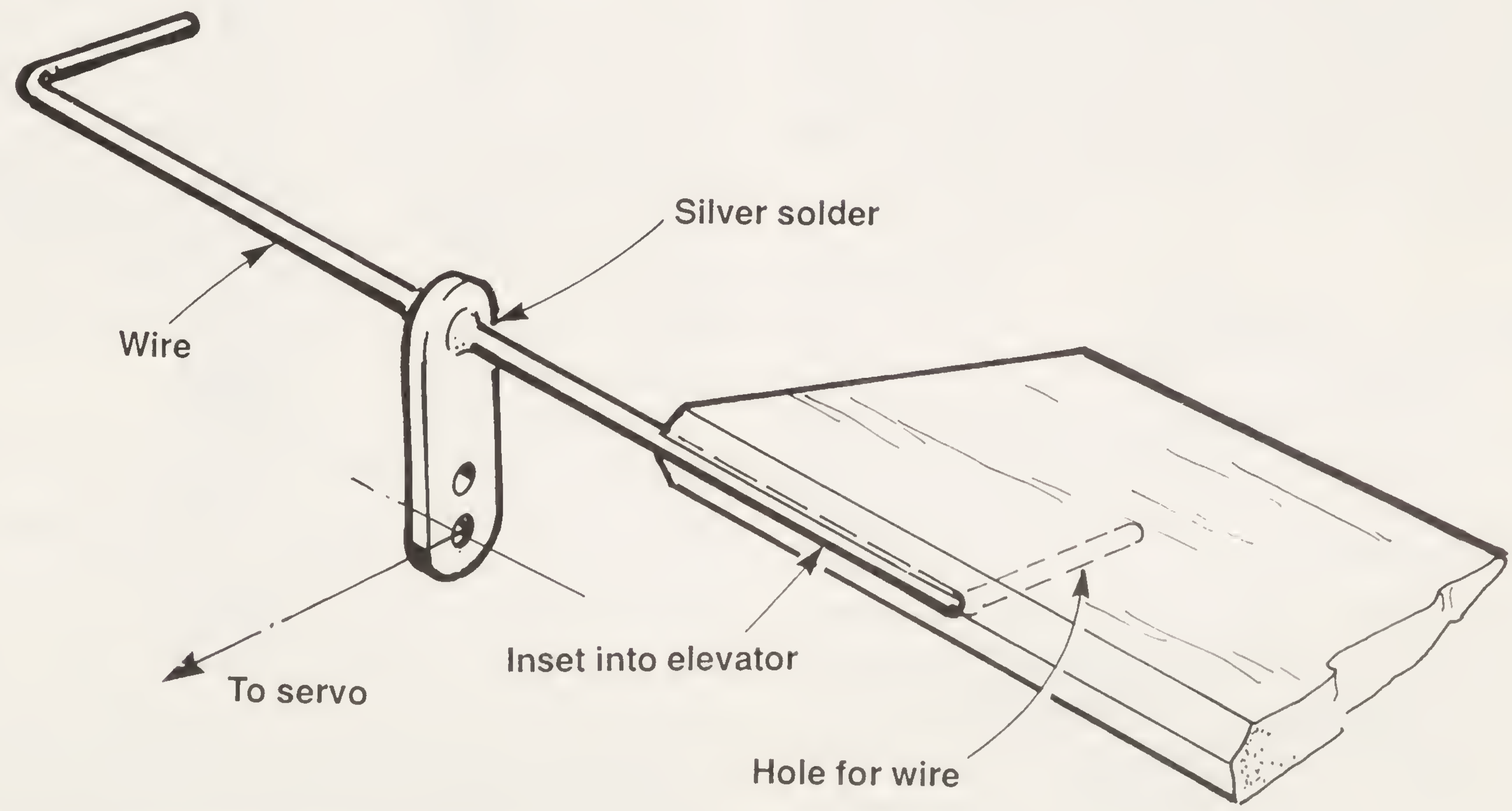


Fig. 3.3 Metal elevator horn assembly.

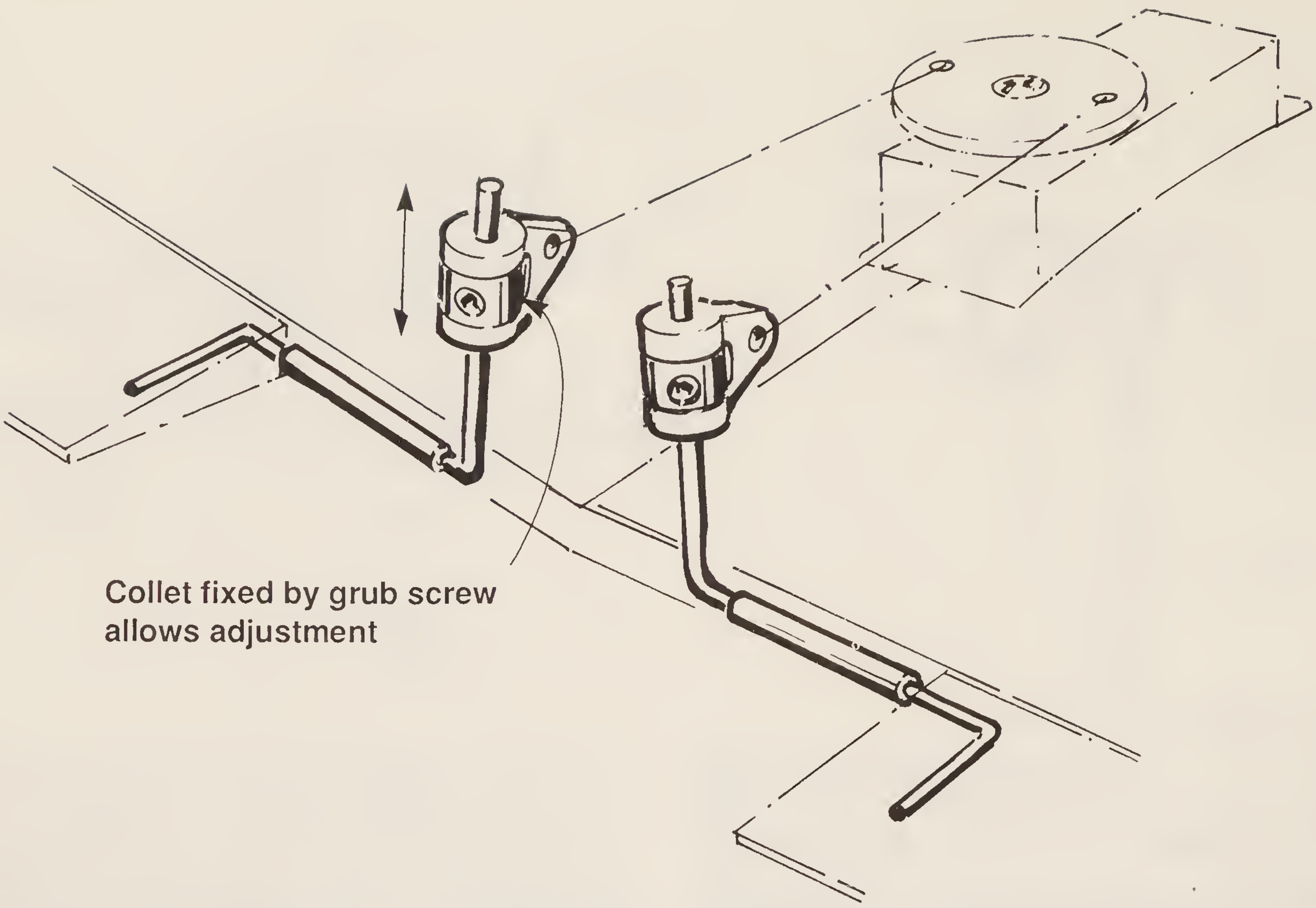


Fig. 3.4 Strip aileron linkage is built in as the trailing edge is fixed. Torque tubes are fixed to wing.

Metal Elevator Horn Assemblies

When elevators are in two halves a wire joiner is often used, with a horn on one half only. This type of horn is both horn and joiner and allows the elevator pushrod end to be kept inside the fuselage. This is another horn that the enthusiast can make for himself from piano wire and scraps of mild steel. However, the soldered connection must be silver solder—ordinary soft solder will not give the required strength.

Strip Aileron Linkage

This comprises both horn and torque rod. Care should be taken to ensure that the torque rod material is stiff enough, otherwise the airflow over the control surface may force the surface back towards the neutral position, reducing control responses. The amount of control surface movement is adjusted by sliding the connecting collar up or down the arm.

Clevises

These represent one means of connecting the pushrod to the horn. They are available in nylon or steel and normally screw onto a nylon or metal rod with a threaded end which allows for fine adjustment of the control surface position. The nylon types often have a tiny ball moulded on the very end of the pin. This 'pops' through the hole in the other half of the clevis to provide a locking action. Where this locking action is not provided a plastic collar may be positioned on the clevis as a belt and braces approach to keep the two halves closed together.

When clevises are used at the servo end of the installation, angular movement is limited about 100 degrees of arc. More than that and the clevis will baulk on the output arm or shaft. This is not usually a problem when the outer holes of the outer arm are used. Where it is necessary to use an inner hole and baulking occurs, the use of ball socket joints will provide a solution.

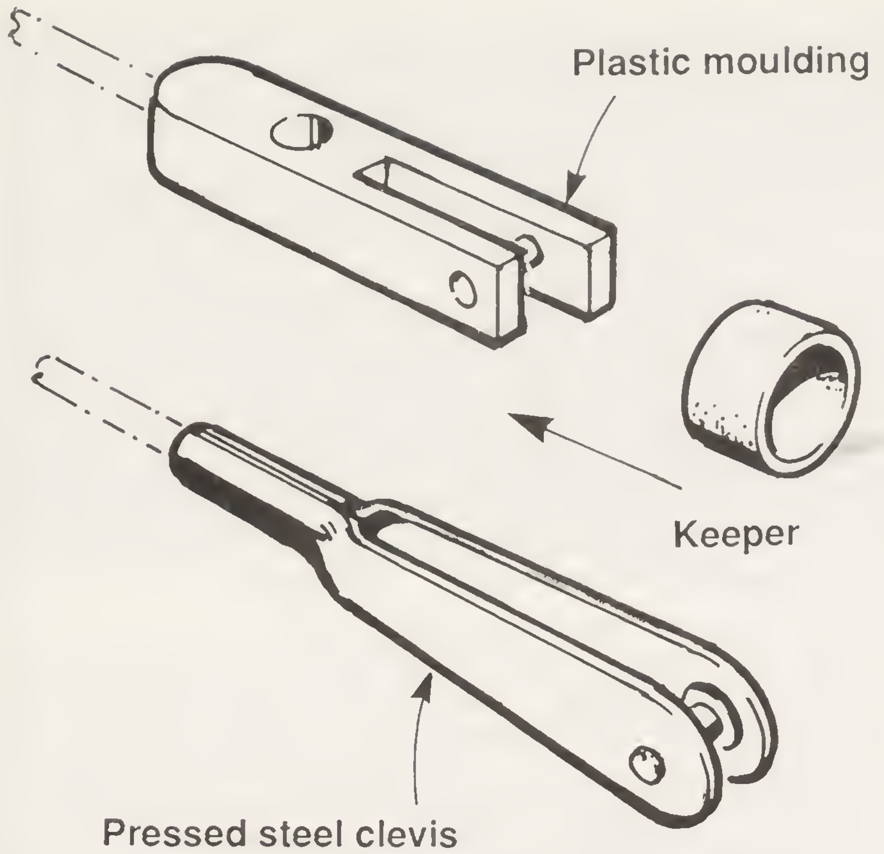


Fig. 3.5 Although many types of clevis are available, they all basically follow the above metal or plastic shapes.

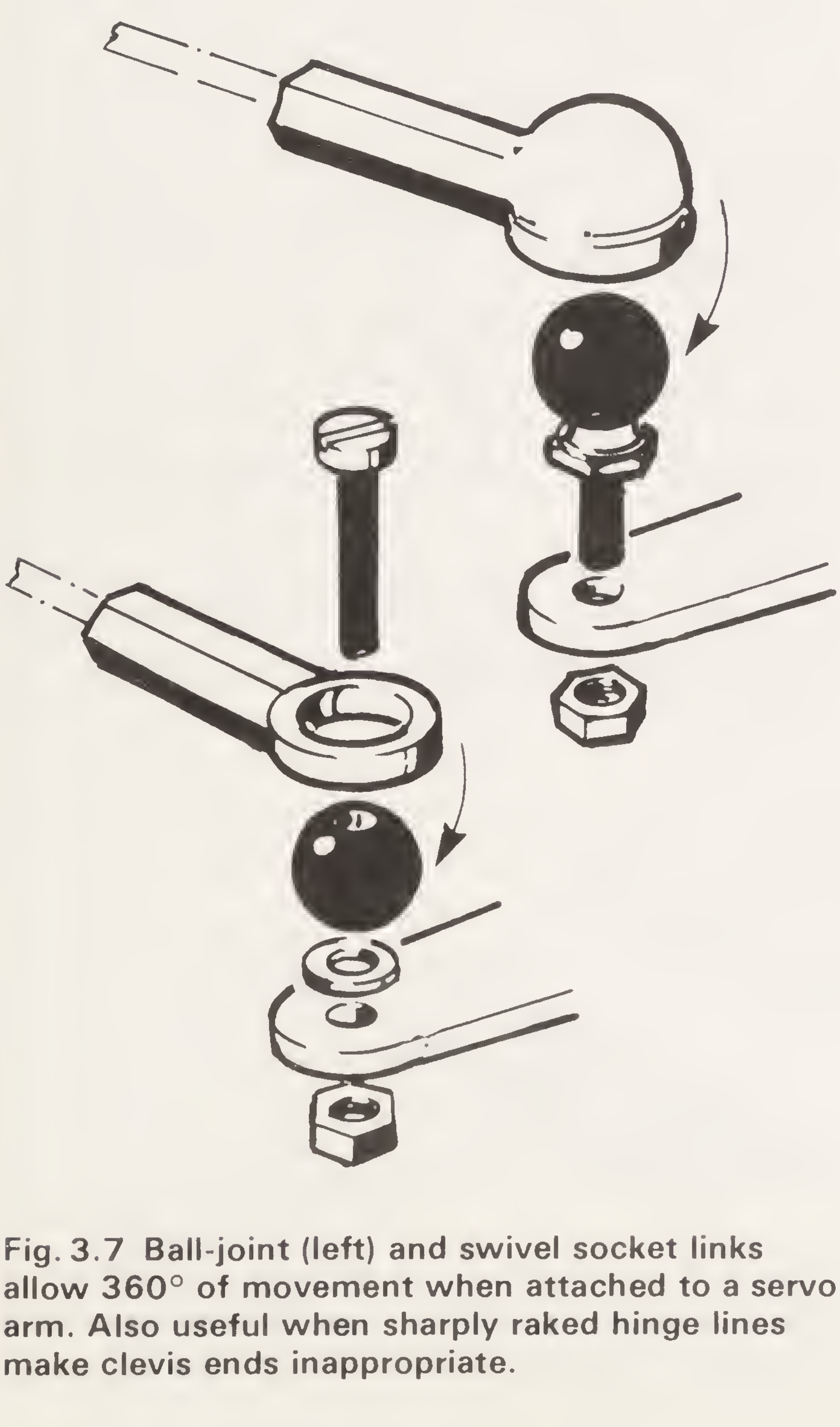


Fig. 3.7 Ball-joint (left) and swivel socket links allow 360° of movement when attached to a servo arm. Also useful when sharply raked hinge lines make clevis ends inappropriate.

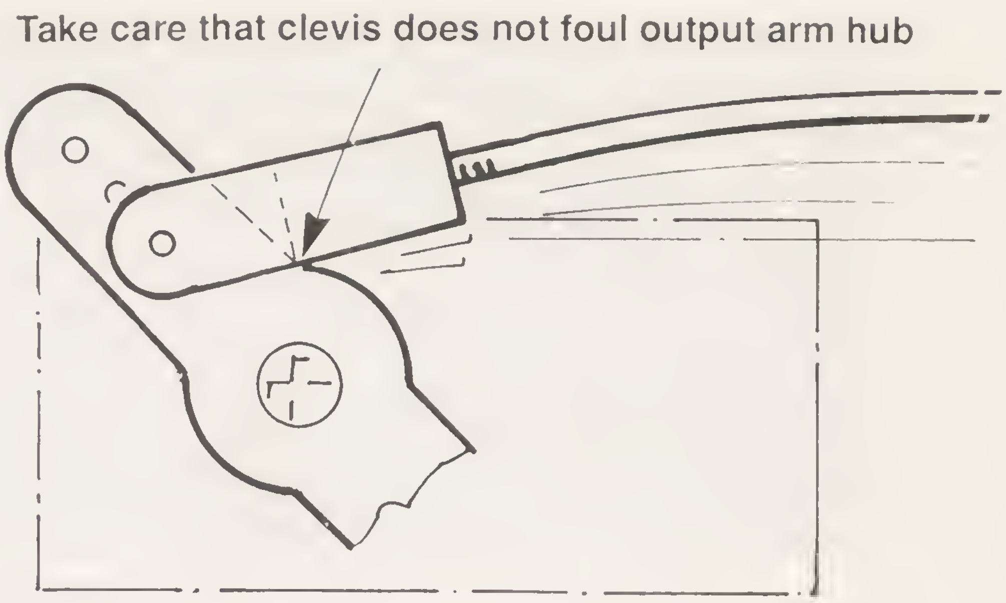


Fig. 3.6

Ball Joints and Swivel Socket Links

Although more expensive than clevis ends, ball joints and swivel socket links are an excellent alternative and make difficult installations easier. Particularly useful where baulking is a problem, they are also helpful where sharply raked hinge lines make the use of clevis ends inappropriate. In both types a brass ball is attached to the servo arm or horn and the socket 'pops' on.

Z Bends

From the sophisticated to the simple. Since the earliest days of aeromodelling, simple wire bends have provided reliable and free connections for control surfaces.

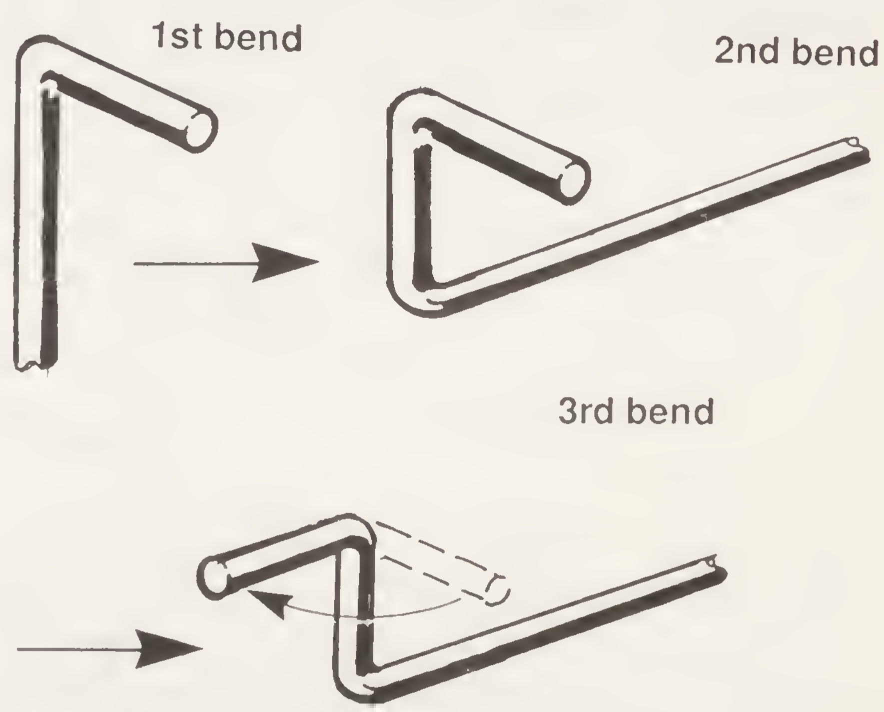


Fig. 3.8 Forming Z bends.

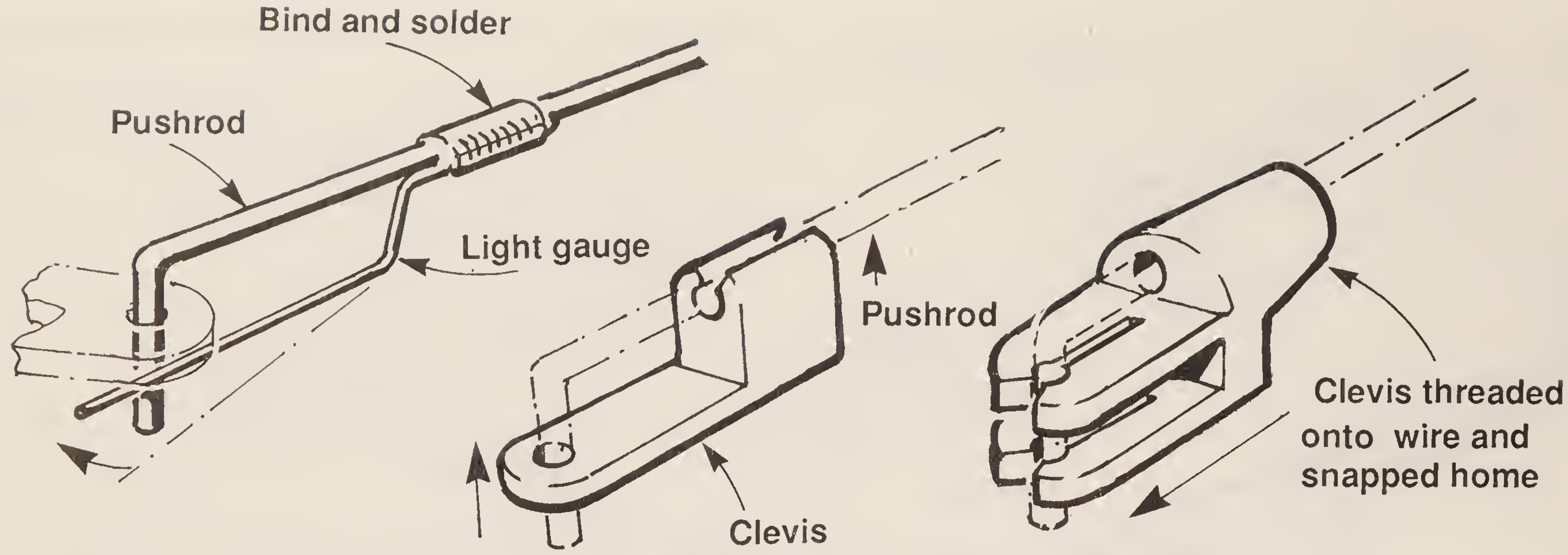


Fig. 3.9 Types of keeper for pushrod ends. That on the left is a simple job for home construction.

The method of forming a Z bend from piano wire is shown on page 27 and it's quick and easy. However, there are disadvantages. Obviously it's not adjustable, so is only useful at one end of a control run. It's also more difficult to connect to the arm. The arm has to be "threaded" onto the bend, a process which means that the arm must be removed from the servo.

CONNECTION METHODS

Pushrods

For the conventional installation with straight control runs, pushrods are just about ideal. History dictates that hardwood dowel, usually of 1/4in to 3/8in diameter is the required material, but I have been using firm balsa strip, albeit of slightly larger section, on models up to 10ft span for many years now. If careful selection produces firm, straight-grained balsa then the resulting pushrod will be lighter and just as reliable as its hardwood counterpart.

Whichever wood is chosen, it must be straight-grained—and straight and true.

The pushrod ends will, of course, be wire and the choice of wire must depend on the end connection. The majority of plastic fittings self-tap onto threaded rod and here the ubiquitous cycle spoke provides a cheap and locally available source. Metal clevises need threaded rod with a compatible thread. Cycle spokes are not compatible so supplies of threaded rod must be obtained with the clevises.

Faced with the model, the plan and the task in hand, pushrod making often looks like a wirebender's nightmare,

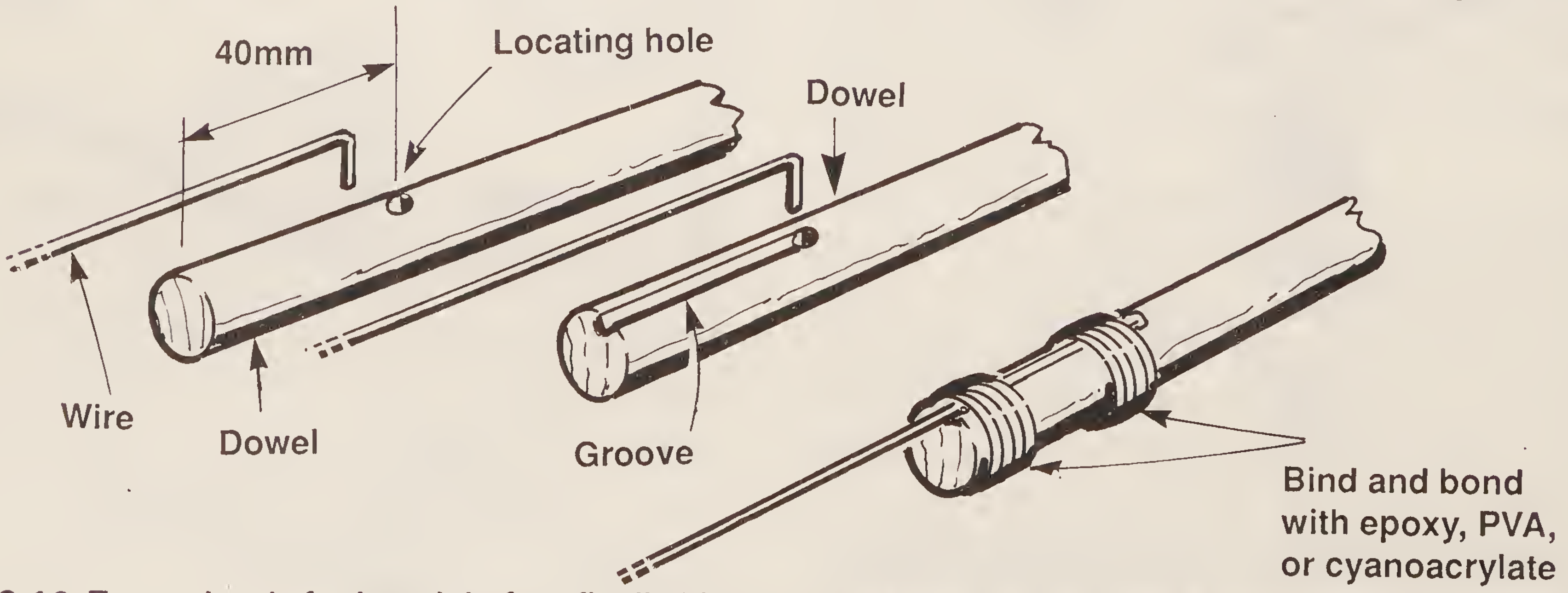
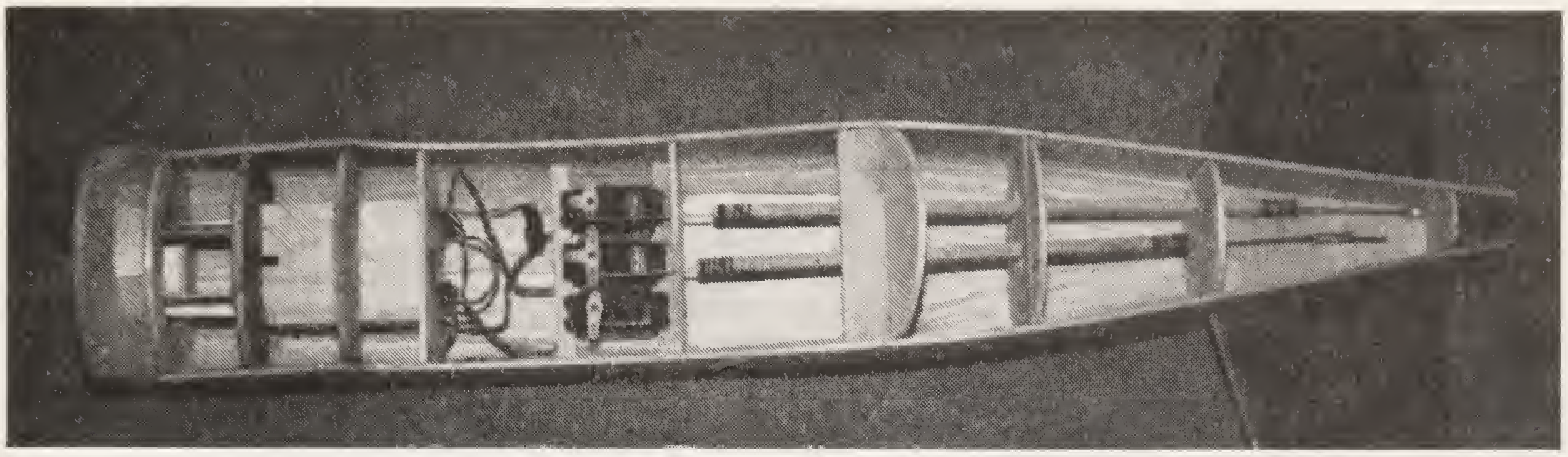


Fig. 3.10 Try pushrods for length before finally binding wire ends. Check that rods do not foul each other, too.



The *Bearcat* model shown earlier demonstrates the use of wood/wire pushrods for elevator and rudder.

particularly at the tail end where multiple bends may be required. Actually the fewer bends the better, and often the plan will give a valuable guide. Begin by screwing the clevis onto the pushrod. Then following the plan bend the wire pushrod carefully to shape. A decent pair of pliers is the minimum requirement and don't forget to bend over the last 1/4in of the wire pushrod. This we need for fixing to the dowel.

Once the tail end has been done the easier front end is next. Cut the dowel to length first—again let the plan be your guide, and then, with the flying surface pegged at neutral, bend the front wire pushrod. Compared with the rear end, this one's going to be straight but again don't forget to allow a 1¼in overlap for fixing to the dowel. The wire will be attached to the pushrod dowel as shown opposite but don't permanently fix the wire in place until both ends have been completed and checked. It's really a case of trial and error and, until you are sure that all is well, use adhesive tape to secure the wire ends in position. It's a good idea to fabricate both elevator and rudder pushrods and try them in the fuselage before binding and glueing the ends. Double check at this stage that the rods are not fouling each other in the fuselage.

Once the pushrod has been checked the assembly is completed by binding and glueing the wire rods to the dowel. Bind with care, and the finished job will look good. I used to use epoxy smeared over the bindings but cyano is better, really soaking into both bindings and wood to make a strong bond.

If binding and glueing seems messy to you, heat shrink tubing is a suitable alternative. I buy mine from the local electronic components stockist. Preparation of the dowel and wire rod is exactly the same as for binding and glueing. The tubing is then placed over the join and shrunk using a hot air gun.

Tube and Cable Systems

The advantage of tube and cable systems is that, because of the inherent flexibility, generally they are easier to install than pushrods, particularly where space at the tail end is restricted. The disadvantage is that the more we use that flexibility, the more we are likely to introduce slop and friction. Care is therefore required to ensure that both these undesirables are kept to a minimum.

Bowden cable

This comprises a stranded steel inner running in a plastic outer, very suitable for short control runs (throttle connections, etc.) but really too sloppy for

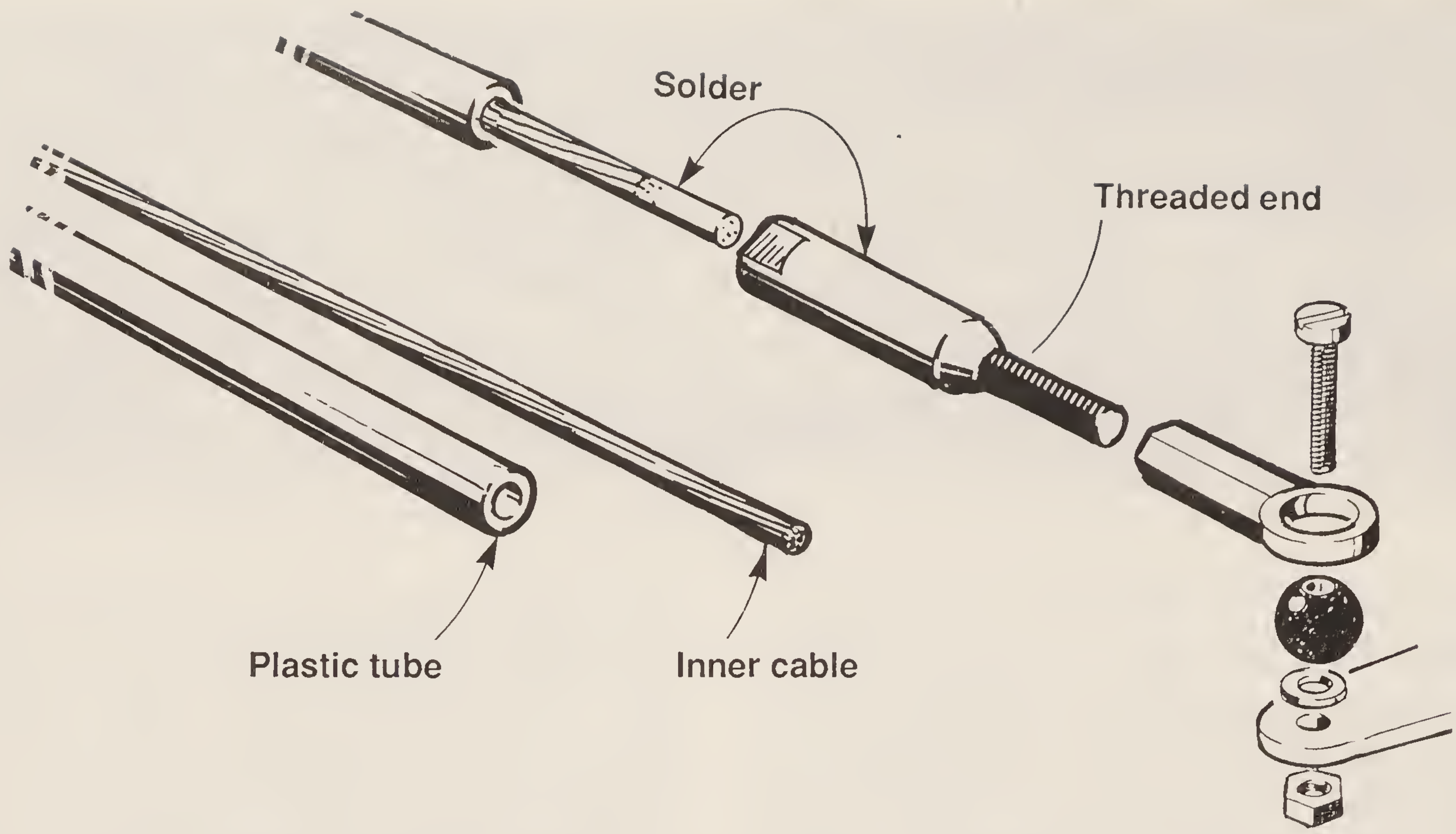


Fig. 3.11 Bowden cable is a good choice for throttle linkages but less suitable for flying surfaces.

longer runs to flying surfaces. Connections to clevises, etc., are made via a turned brass cable-to-link adaptor which is soft-soldered to the end of the steel wire cable.

Nylon Tube and Nylon Rod

This is a plastic rod running in a plastic tube and various designs are available from different manufacturers. No effort has been spared by some manufacturers to reduce the problems of slop and friction. Most of the new systems feature a fluted inner to reduce contact friction and the plastics used have been carefully chosen for their low coefficient of friction values and temperature stability. Nevertheless, care again is required and bends avoided if sloppiness is to be kept to a minimum.

Connection to fittings is made by screwing a threaded rod up inside the inner cable, leaving enough protruding for attachment of the fitting.

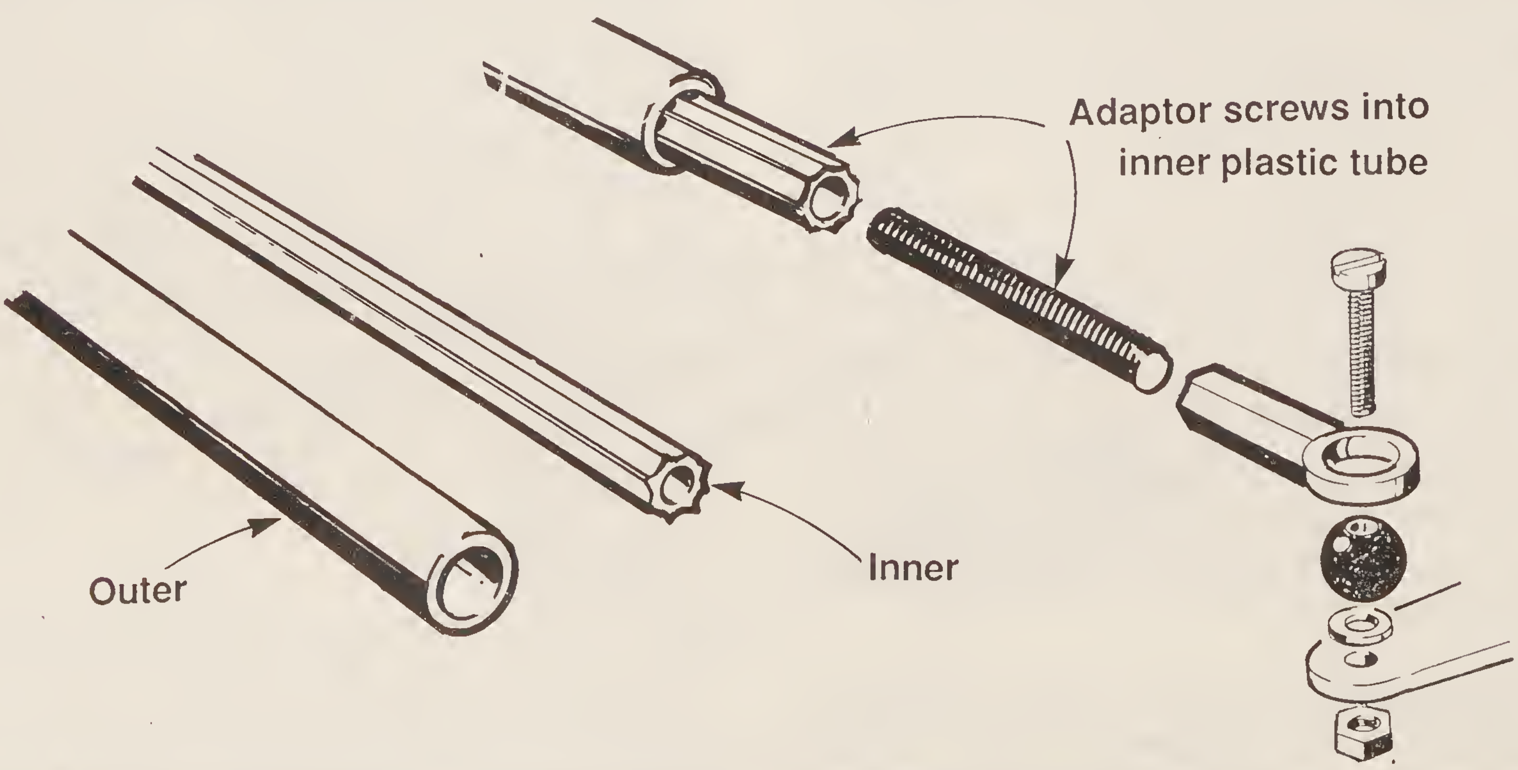


Fig. 3.12 "Nylon tube and rod" is now usually tube-in-tube and of low-friction plastic other than nylon.

Piano wire pushrods on the author's large Cub model. Note bolt-on elevator horn and use of both plastic and metal clevises.

Plastic Tube and Piano Wire

Where control runs can be kept straight, plastic tubing and piano wire is a useful alternative to pushrods. This is the most slop-free of the tube and cable systems but the rigidity of the piano wire makes bends of any significance impossible. My quarter-scale Piper Cub uses this system for rudder, elevator and tail wheel control and provides accurate slop-free control with reliable neutrals. It does, however, mean that a significant amount of metal is running fore and aft down the fuselage so is not recommended where it is also desirable to run the receiver aerial inside the fuselage. Attachments to clevises, etc., is, like Bowden cable, by soldered connections.

The requirements of any control system are that it shall be smooth, easy running and slop-free. To achieve this with any tube and cable system calls for great care on installation. We have already said that cable runs should be as straight as possible; the cable also should be regularly supported along its length and it may be necessary to build in cross-members across the fuselage to provide adequate support.

Cable exits should be planned so that

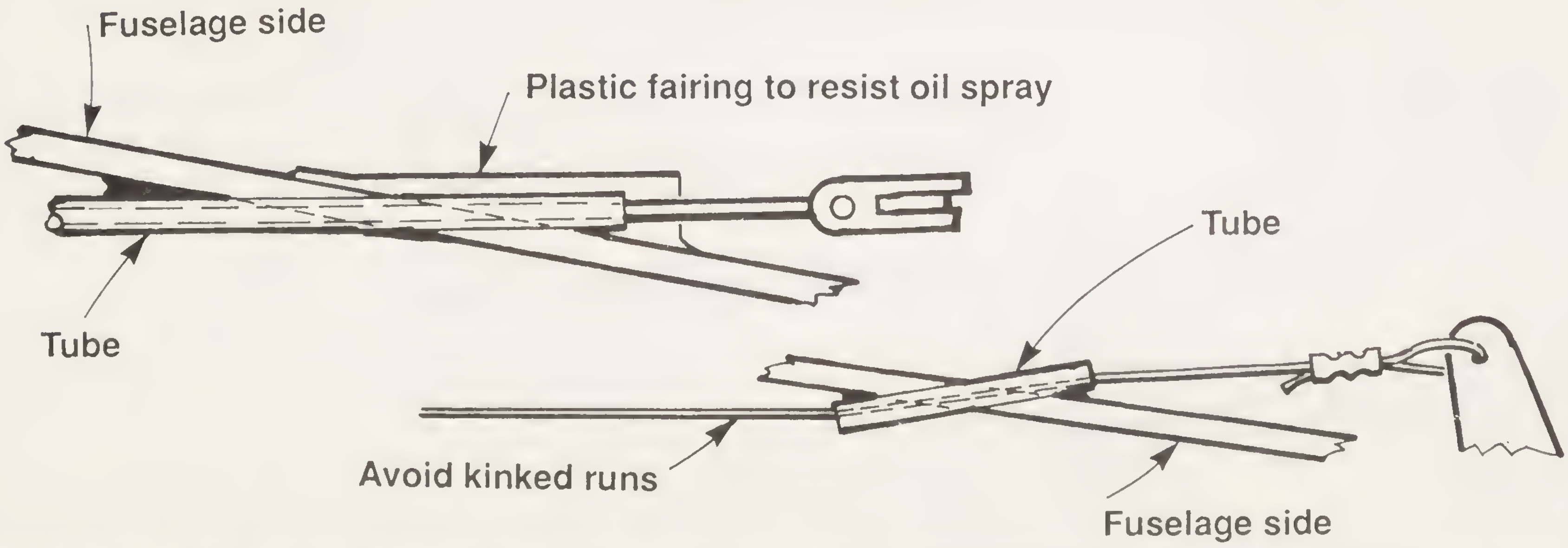


Fig. 3.13 Using exit fairings. Tube outer end inside fairing gives maximum protection against oil etc.

they are not likely to be sprayed with oil from the engine. Capillary action seems to draw oil up cable systems and the result is a stiff and sticky mess that will overstress the servo and flatten the receiver battery very quickly. If exhaust effluent is found to be a problem exit fairings are commercially available and must be used.

Closed-Loop Systems

The closed-loop system used for model control is almost identical to the control systems used on full-size light aircraft. For model use it is usually limited to rudder and elevator applications but can be used for aileron controls where scale appearance is paramount. Properly done, closed loop is easy-running and slop-free and although, like any linkage system, straight runs are best, it is possible to cope with changes of direction via guides and pulleys.

The basis of closed-loop is the use of a flexible, stranded cable instead of a pushrod. Fishing trace is the most commonly used cable and of course the action is a pull/pull action. Two lengths are required per flying surface and double or double-sided horns are required.

The accompanying diagram shows a basic system. This is both simple and cheap—all that is required is two lengths of fishing trace and some short lengths of brass tube. With both the servo and the surface held at neutral, the cables are run and terminated as shown. It is not necessary to make the cables too tight. Indeed, excessive tightness leads to servo output bearing wear and can also cause stiffness. Just tight enough to give slop-free surfaces, and no tighter.

Adjustment for neutral and tension is given by the clevis ends and lengths of threaded rod in the system.

Of course, the industry has come to our aid here and a good selection of accessories is available, for the modeller who wishes to make his own.

Be careful with clevises. Any residual tension in the wire will be added to the tension to which the wire is subject when the servo operates. If this line tension is too high the total tension could be enough to force open the clevis and disconnect the linkage. So, never overtighten control wires and select your clevis with care, opting for the stronger type if there is ever any doubt.

You will be lucky indeed if the control wires on your model are able to take a straight line. More likely than not the wires will need to round a bend.

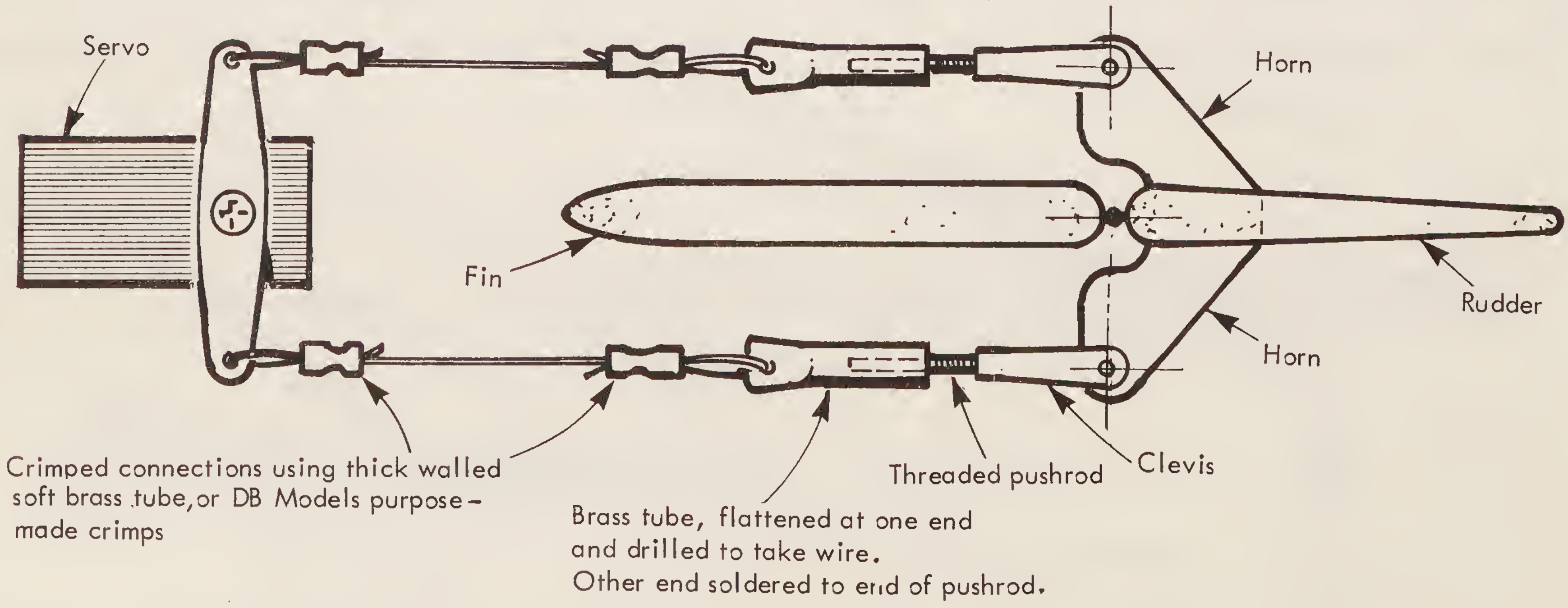


Fig. 13.4 Adjustable closed loop arrangement.

PFTE or nylon semi-rigid tubing is ideal for this; remember it doesn't want to be a close fit over the wire, it's only a guide and must not add significantly to the overall friction of the system. Be sure that plastic tubing is reasonably straight before use; immersion in boiling water for a few minutes will soon make it supple. When fixing to the model, support it along its length to avoid any residual curl creeping back.

Plan control runs so that wires do not touch. If they do, large amounts of electrical noise may be generated causing catastrophic radio failure. If necessary use an extra guide to route one wire away from its neighbour. This problem of electrical noise not only applies to closed-loop control cables. Any metal to metal contact should be avoided, even tiny contacts such as the metal pin on some nylon clevises and a metal elevator horn can cause problems. Some R/C systems are more tolerant than others but common sense dictates that metal to metal connections are best avoided.

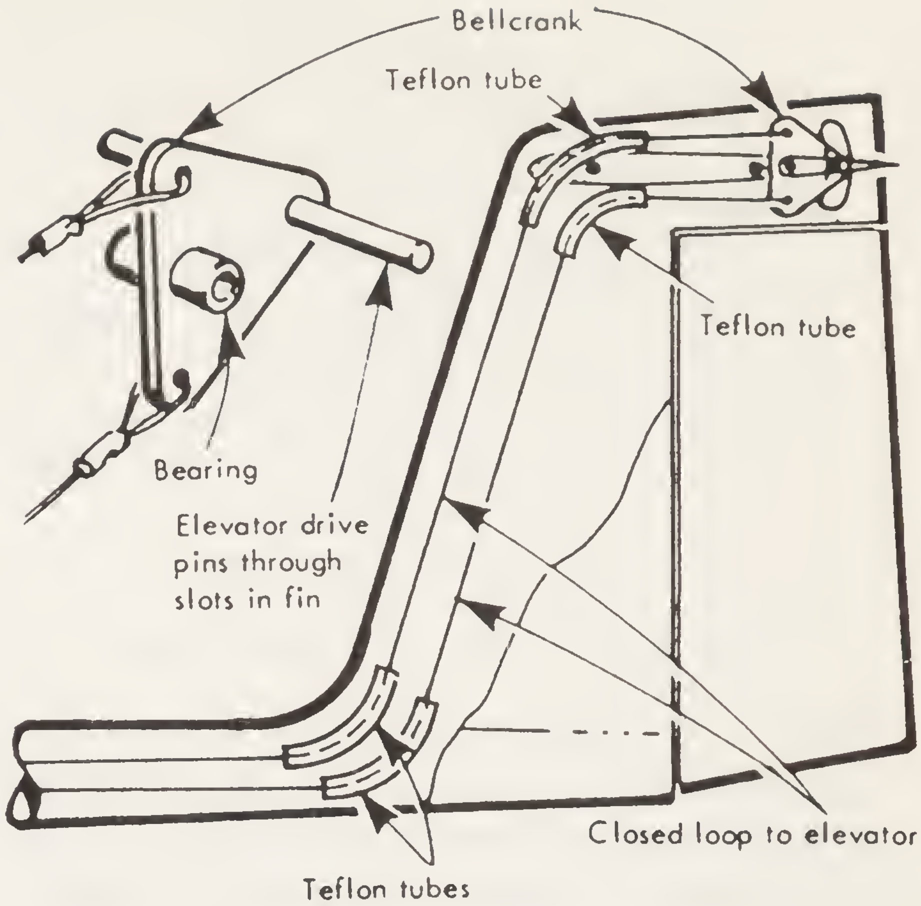


Fig. 3.15 Closed loop systems need not be only for long straight runs, as this T-tail arrangement shows.

Throttle Linkages

Throttle linkages are usually the shortest of the control linkages. They are fitted in a very restricted area and require precise adjustment. They are, therefore, often the most difficult to get right. A further problem with throttle linkage comes from the likely ingestion of oil and dirt and the consequential stiffening of the linkage and overloading of the servo.

Planning for the throttle linkage is best done before building commences. Sketch onto the plan the engine position, draw in the tank and servo and then plan the route. The route should be as straight as possible and where a direct line can be achieved plan to use a piano wire pushrod inside a nylon tube. Where bends are unavoidable the Bowden cable is next best but bends must be kept to a minimum. Consider, too, the sense of servo rotation, for this will dictate on which side of the servo disc your connection has to be made. If servo reversing is available from your

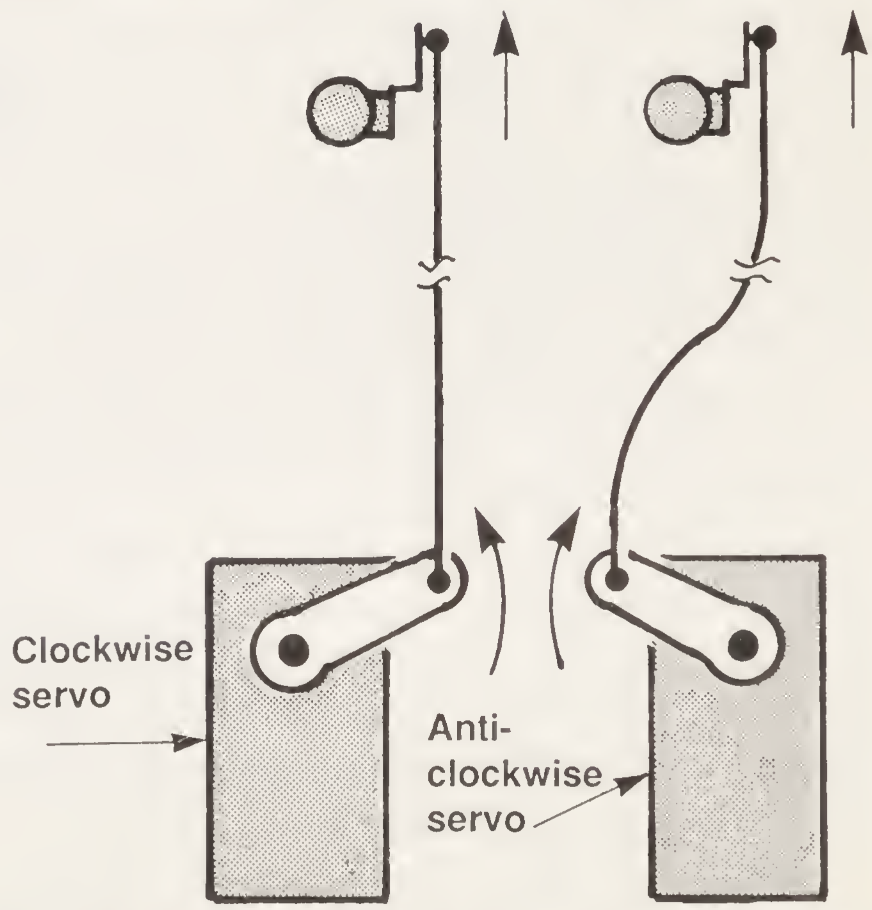


Fig. 3.16 Different servo rotation for the same direction of Tx stick movement.

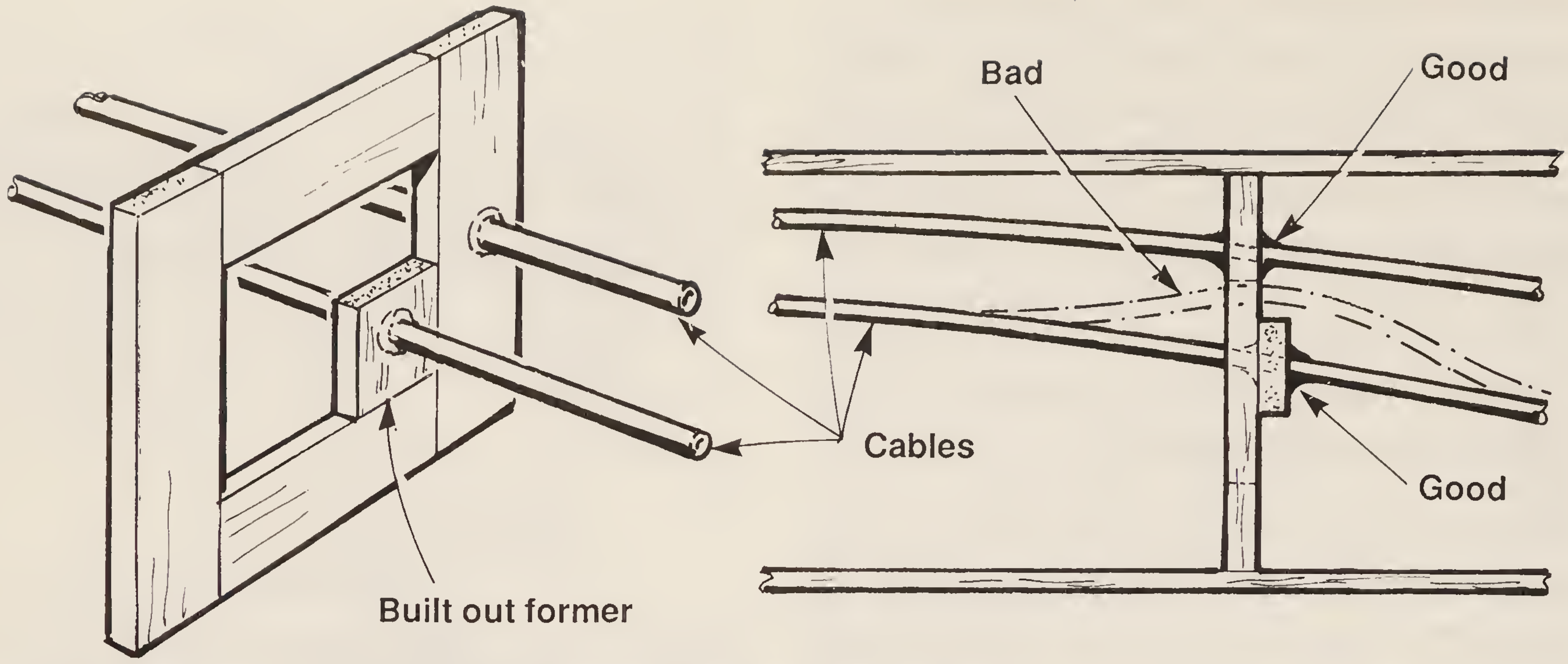


Fig. 3.17 Treatment of cable runs to reduce both friction and slop.

transmitter then obviously you have no need to worry. The conventional sense of throttle operation is for the throttle to be fully open with the transmitter stick forward. With the stick *and trim* fully back, the carburettor barrel should be completely closed. Keeping the throttle in the closed position we now have to arrange the linkage so that fully advancing the trim control just opens the barrel. The idea, of course, is that stick and trim forward is full power, stick and trim back cuts the engine, whilst stick back and trim forward gives us a reliable tickover. The tickover position can only be accurately adjusted once the model is finished and the engine installed, but as a rough guide the throttle barrel should open about 0.5-1 mm (about the diameter of a modelling pin). This will do for now, fine adjustments come later.

All this sounds rather more difficult than it is. The choice of holes on the carburettor throttle arm and the servo arm give a reasonable range of adjustments. However, we must ensure that the linkage is arranged to allow the servo arm its full travel. If it is baulked at either end, strain and high current consumption will result.

Space at the engine end is often restricted and this makes the fitting of a clevis difficult. If the throttle lever is nylon a simple Z bend may be used with a piano wire [music wire in the USA] pushrod although this will mean that the throttle arm or even the carburettor has to be removed to thread it over the Z. If Bowden cable is used a piano wire Z should be bound and soldered to the cable. Life is made easier if space permits a clevis or ball and socket to be used at the engine end and even easier if a straight run allows a rigid pushrod. Substitute a cycle spoke for the piano wire to provide a threaded end for the clevis.

Connecting the clevis to Bowden cable is achieved via a threaded adaptor soldered to the cable.

Connecting the throttle linkage at the servo end poses fewer problems although again space may be restricted by firewalls or fuselage sides. Here a clevis or ball and socket joint should be used on a threaded rod to provide adjustment. Leave the fixing of the outer cable until last. Thoroughly check the system for freedom of movement and accuracy of adjustment and then secure the cable outer in place. The smoothness of the outer will prevent epoxy glue from bonding so roughen the outer with glass-paper. Where the cable passes close to rather than through a former, build out the former to provide support.

Chapter 4
Ailerons

THE TWO types of ailerons are illustrated: they are inset ailerons and strip ailerons. Inset ailerons are identical to the ailerons used on full-size flying machines and employ pushrods and bellcranks. Again the plastics moulding industry serves the modeller well and we are spoiled for choice.

Fitting of the pushrods and bellcranks must be done as the wing is built. Bellcranks are mounted on ply plates glued between ribs and holes in ribs for the pushrods to pass through are better

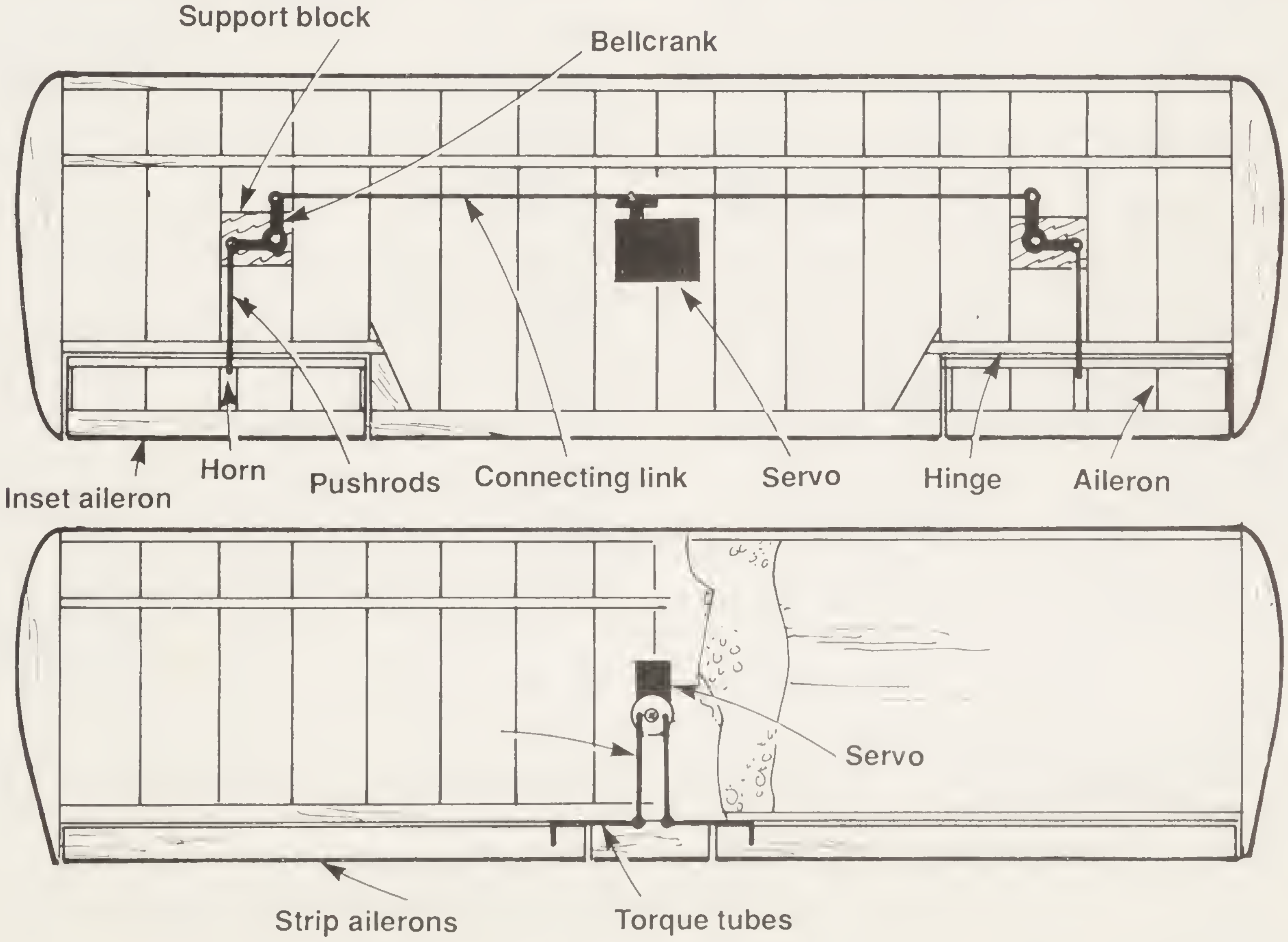


Fig. 4.1 The two basic types of aileron require quite different linkage arrangements.

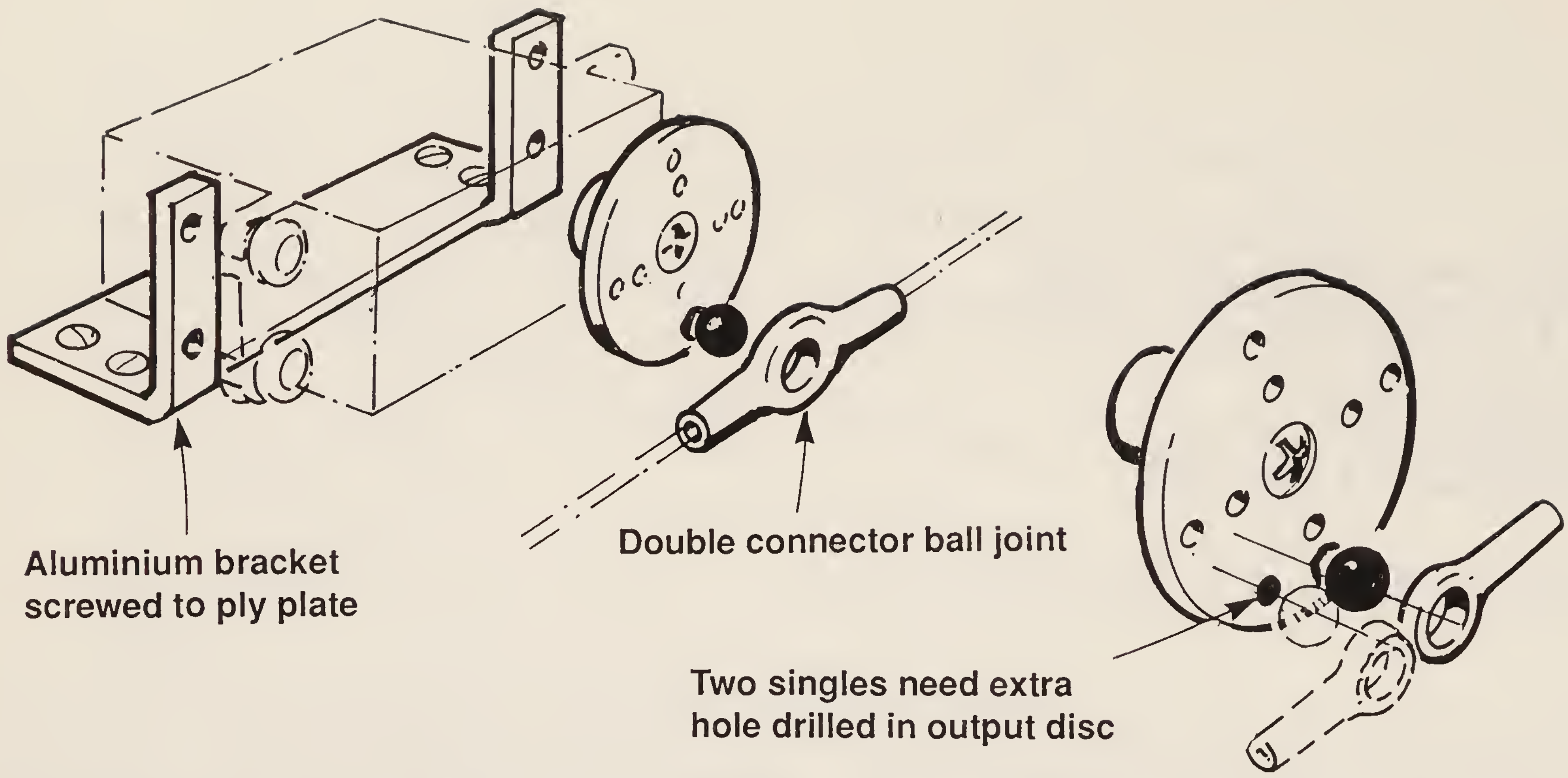


Fig. 4.2 Double connector ball joints make the installation of inset aileron servos very much easier.

made before the wing is assembled. Careful alignment of pushrods and bellcranks is required and where push-rods pass through ribs, small pieces of plastic tube provide support and reduce slop. Connecting pushrods to the aileron servo is often a problem with inset ailerons. The servo, which usually lies on its side inside the centre box, is difficult to connect to. Ball joints are useful here and can be "popped" onto the servo after the servo has been installed in the box. Connecting push-rods to bellcranks requires a fit and forget method and Z bends provide the answer. Care must be taken to ensure that the lengths are right. Z bends are not adjustable!

With both types of ailerons it is sometimes desirable to build a little differential into the movement. Because of the lift and drag characteristics of some wings it is required to have the up-going aileron moving up more than the down-going aileron is going down. Put simply this ensures that the aileron drag aids the turn instead of inducing adverse yaw.

Differential is easily obtained with inset ailerons by using differential cranks. These are available in two types with the arms at more or less than 90 degrees.

The diagram shows the principle and is simple to understand once it is appreciated that the differential is achieved by changing the angle of the bellcrank to more or less than 90 degrees and losing pushrod movement in the radial movement of the arm.

The type of bellcrank required to provide the "more up than down" differential described earlier is governed by the mounting position of the control surface horn. If the horn is mounted on top of the surface, i.e., 'up' is a pull action of the pushrod, then a bellcrank angle of more than 90 degrees is required. The opposite is true if the horn is mounted under the surface.

Having obtained our aileron differential it is easy to inadvertently lose it or indeed augment it by careless horn installation. To ensure that unwanted differential is not introduced at the horn it is necessary to arrange the horn so that a line from the horn pivot point to the bellcrank is at 90 degrees to a line from the horn pivot point to the hinge line. It follows of course that differential

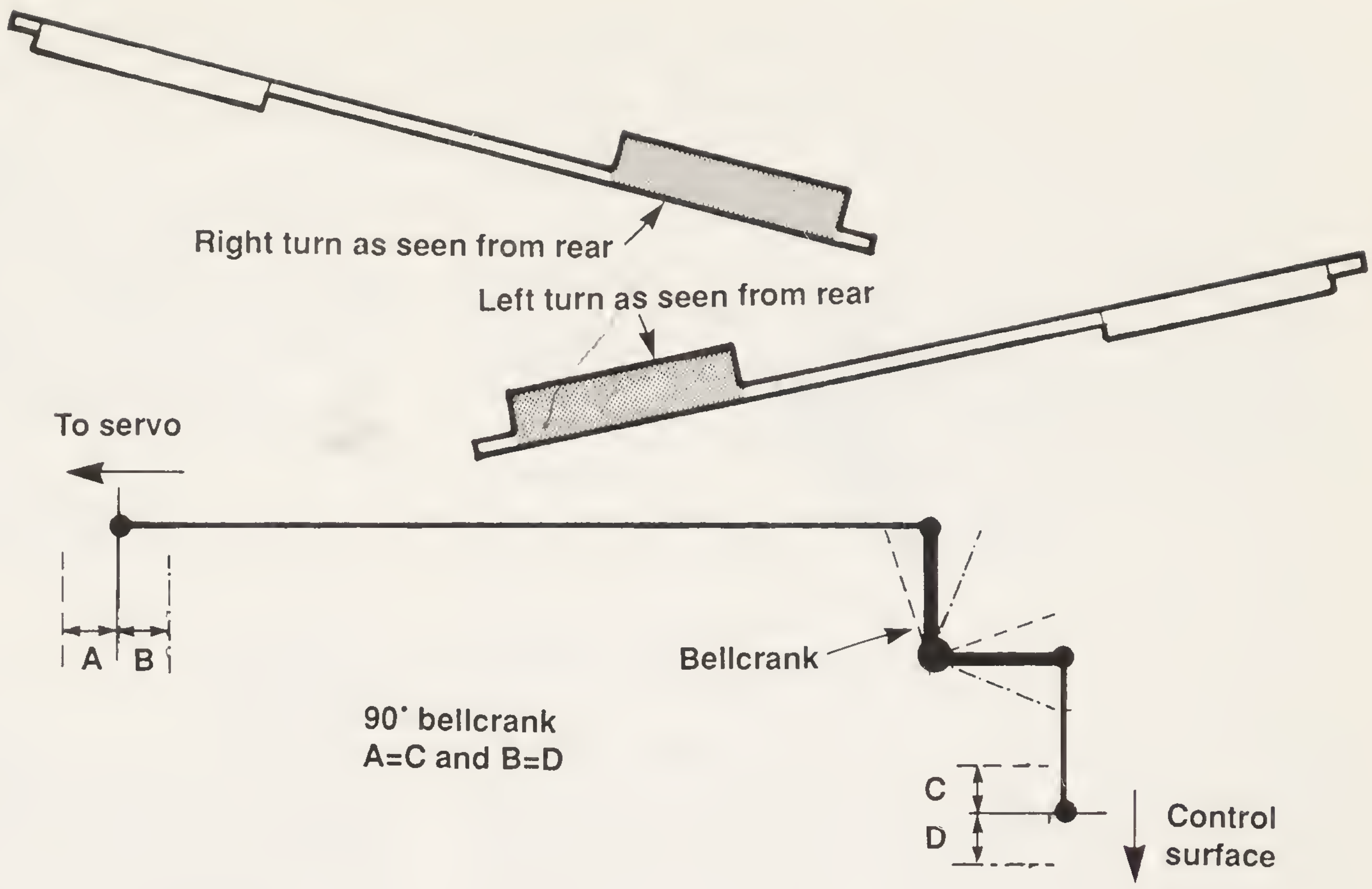


Fig. 4.3 A 90° bell-crank gives equal up/down movement.

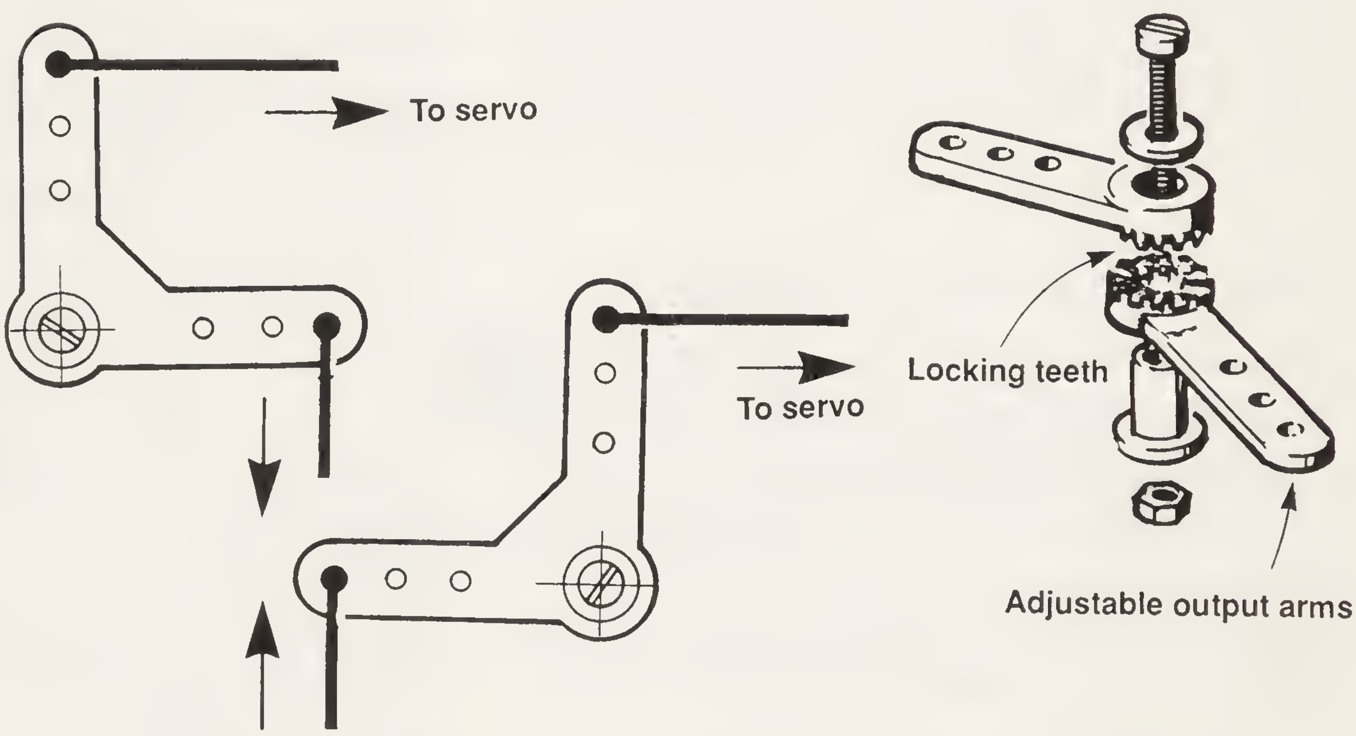


Fig. 4.4 Control surface movement can be reversed if required by turning bellcrank 180°. Far right, an adjustable bellcrank for angles other than 90°.

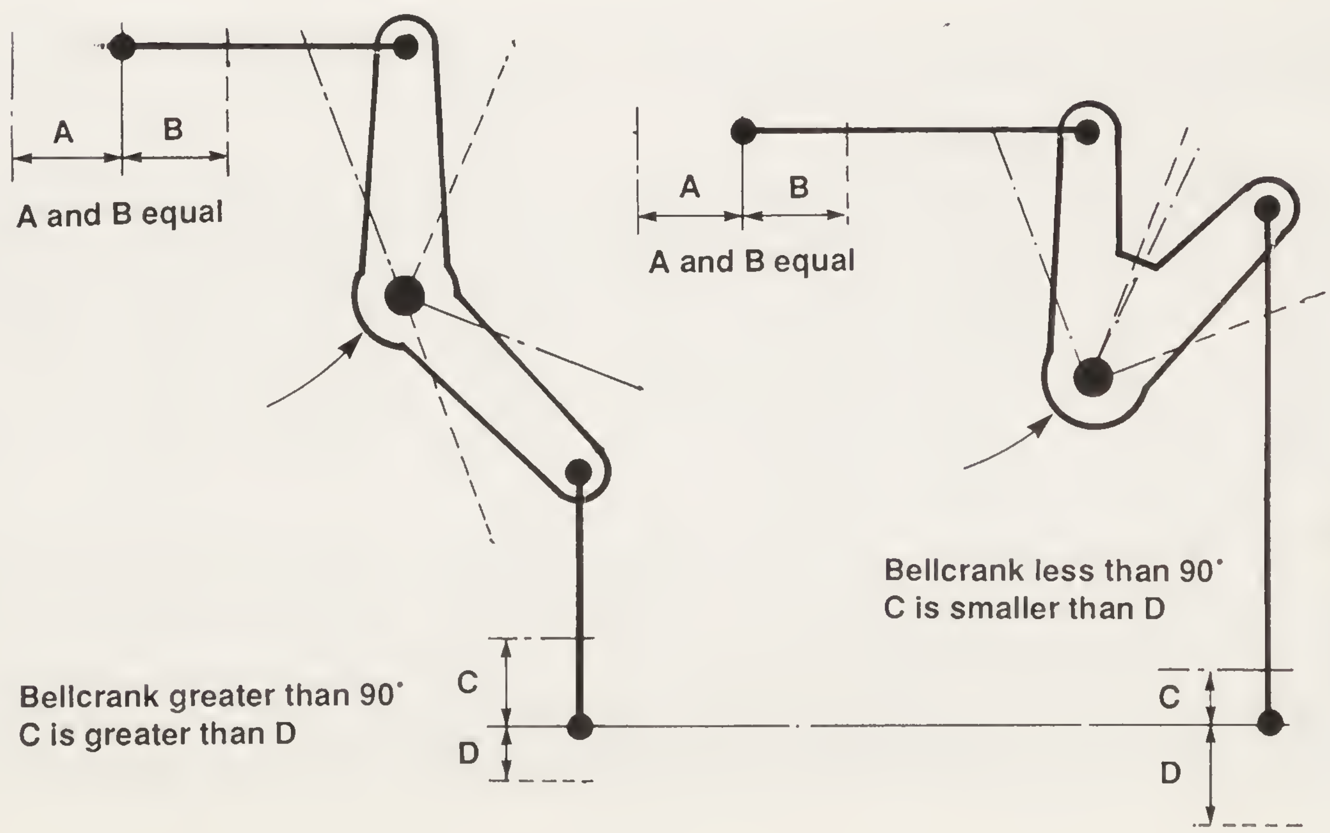


Fig. 4.5 Effect of change of bellcrank angle on up/down control relationship.

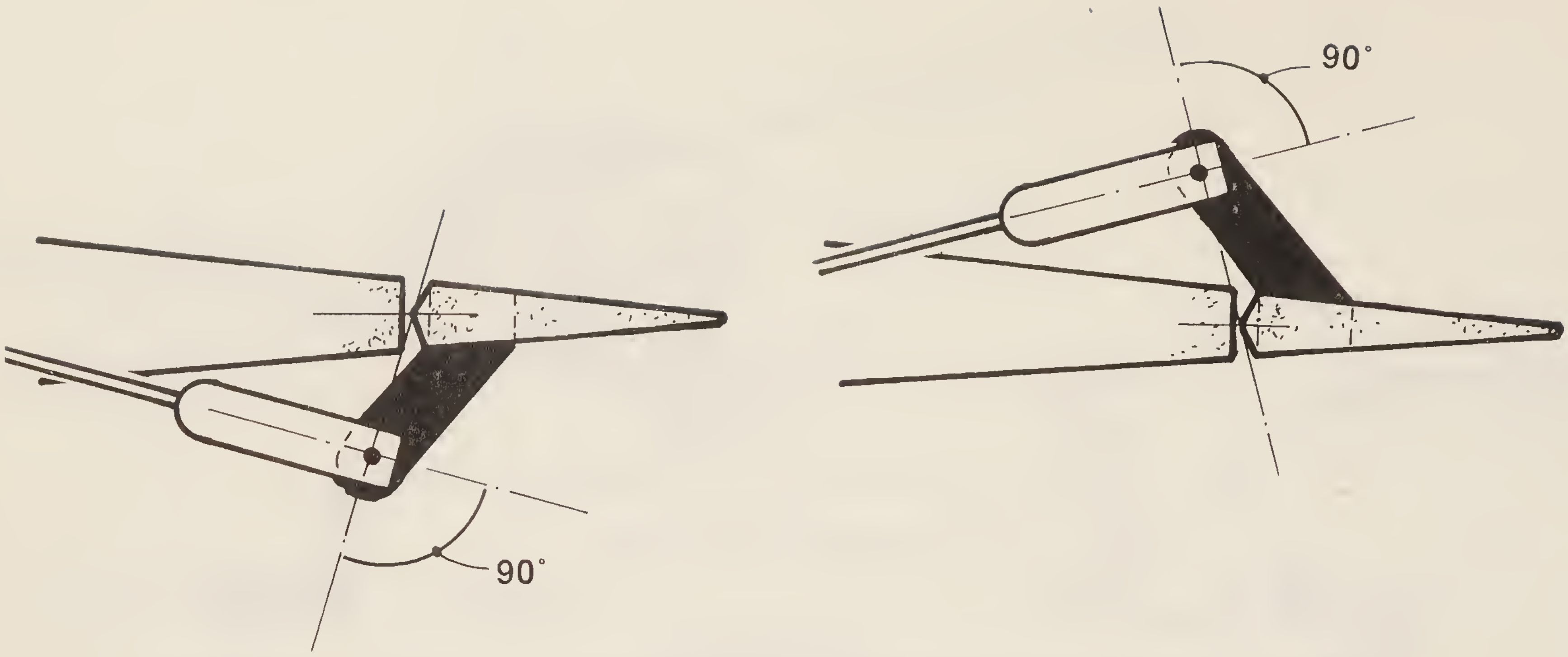


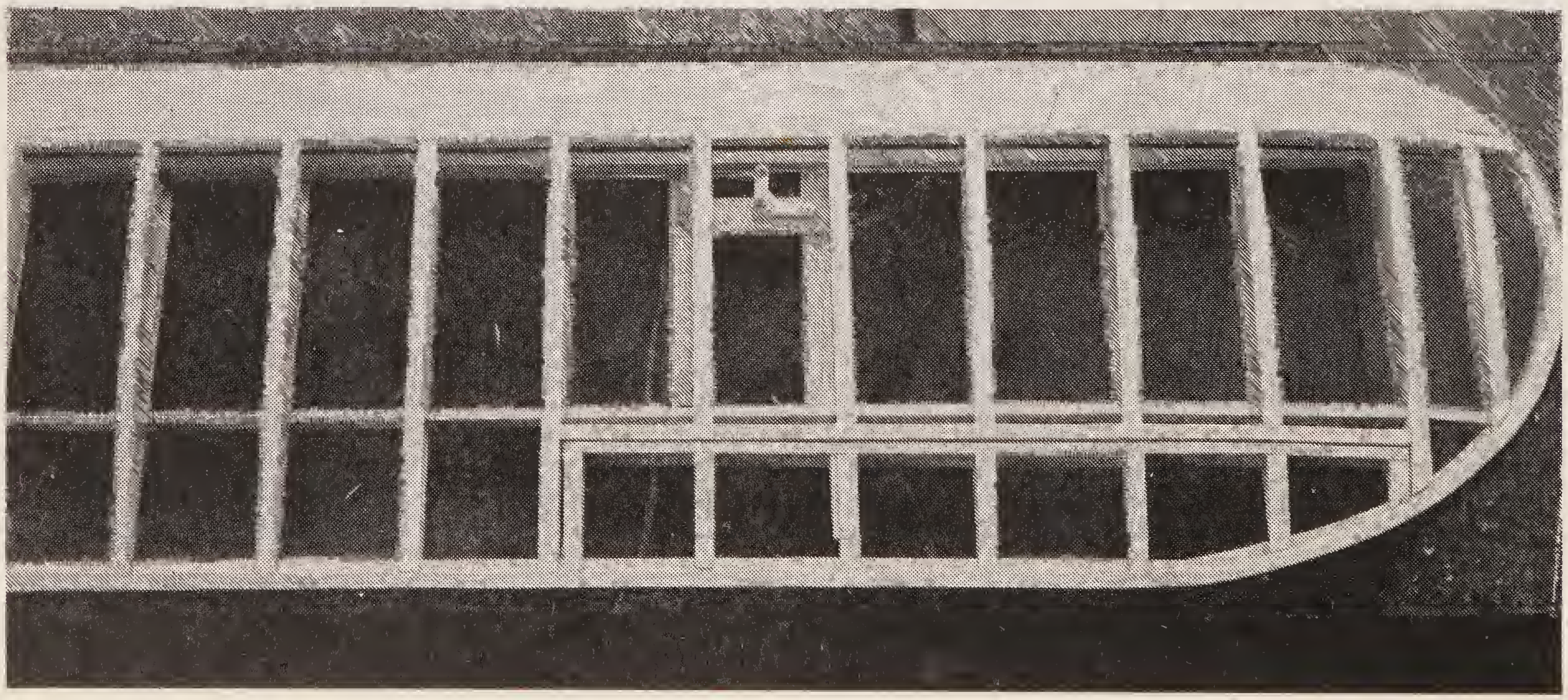
Fig. 4.6 It is important to take note of the angles shown above to achieve neutral connection.

can be deliberately built into the horn assembly. Raking a bottom-mounted horn rearwards will give the desired more-up-than-down action as will raking to a top-mounted horn forward.

Tube and Cable Aileron Linkages

Where wing design makes the installation of pushrods and bellcranks difficult, inset ailerons may be operated by using a tube and cable system. This method is popular for foam wings but does produce unavoidable slop and, unless great care is taken, a "sticky" action that will result in poor neutrals.

Because the cable must bend through 90 degrees in a relatively small space, two problems arise. First the friction between the inner wall of the outer and the inner cable increases considerably. This is inversely proportional to the bending radii. Second, before the control surface moves any gap between the inner and outer has to be taken up. Thus the first part of the servo movement is lost and again sloppy neutrals are inevitable. Of course we can make some attempt to reduce these undesirable characteristics. Modern purpose-made tube and cable systems are infinitely better than Bowden cable and should be used. As much space as possible should



The bellcrank position on an inset aileron. Note aileron has not been cut free yet, for good alignment.

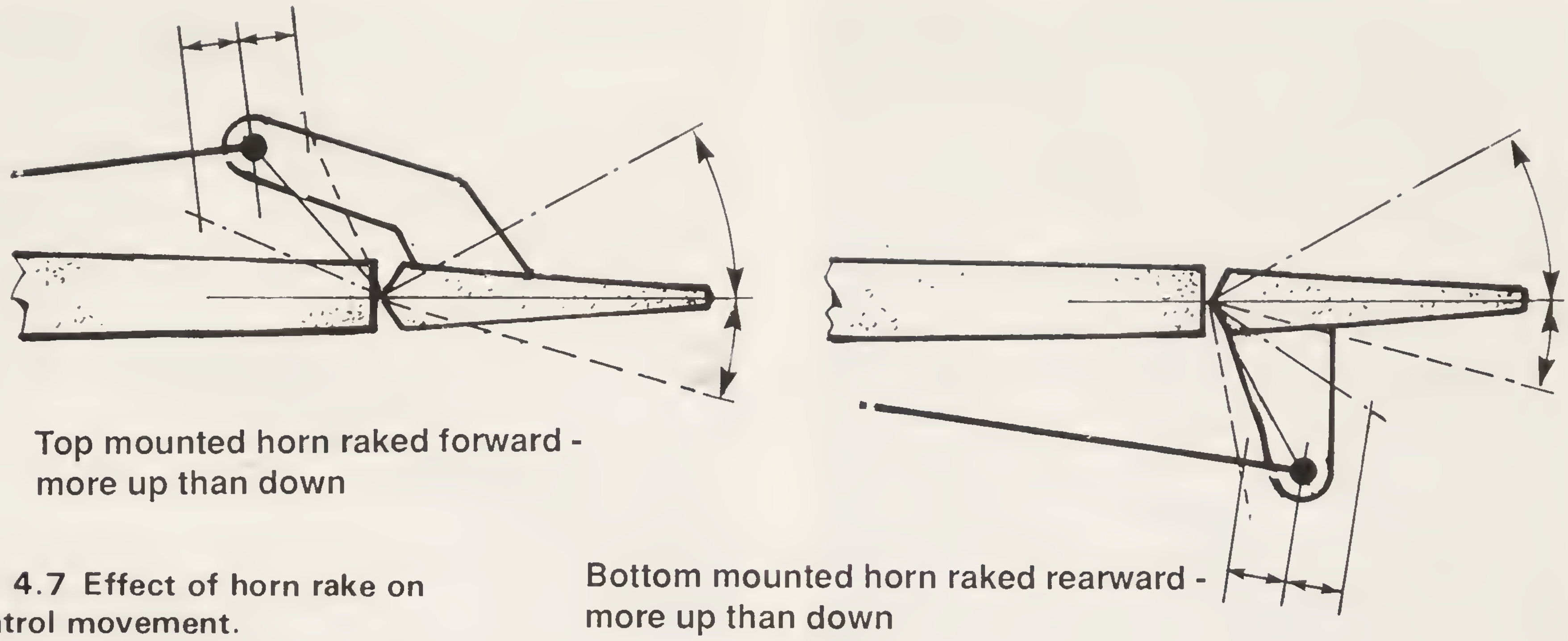


Fig. 4.7 Effect of horn rake on control movement.

be allowed for the 90 degree bend ensuring that the exit point accurately lines up with the horn axis.

Finally, tube and cable systems need regular checks. The ingress of fuel residues and dirt will quickly stiffen up the system and impose unacceptable loads on the servo. When this happens, removing the inner cable and cleaning with a solvent is the only answer.

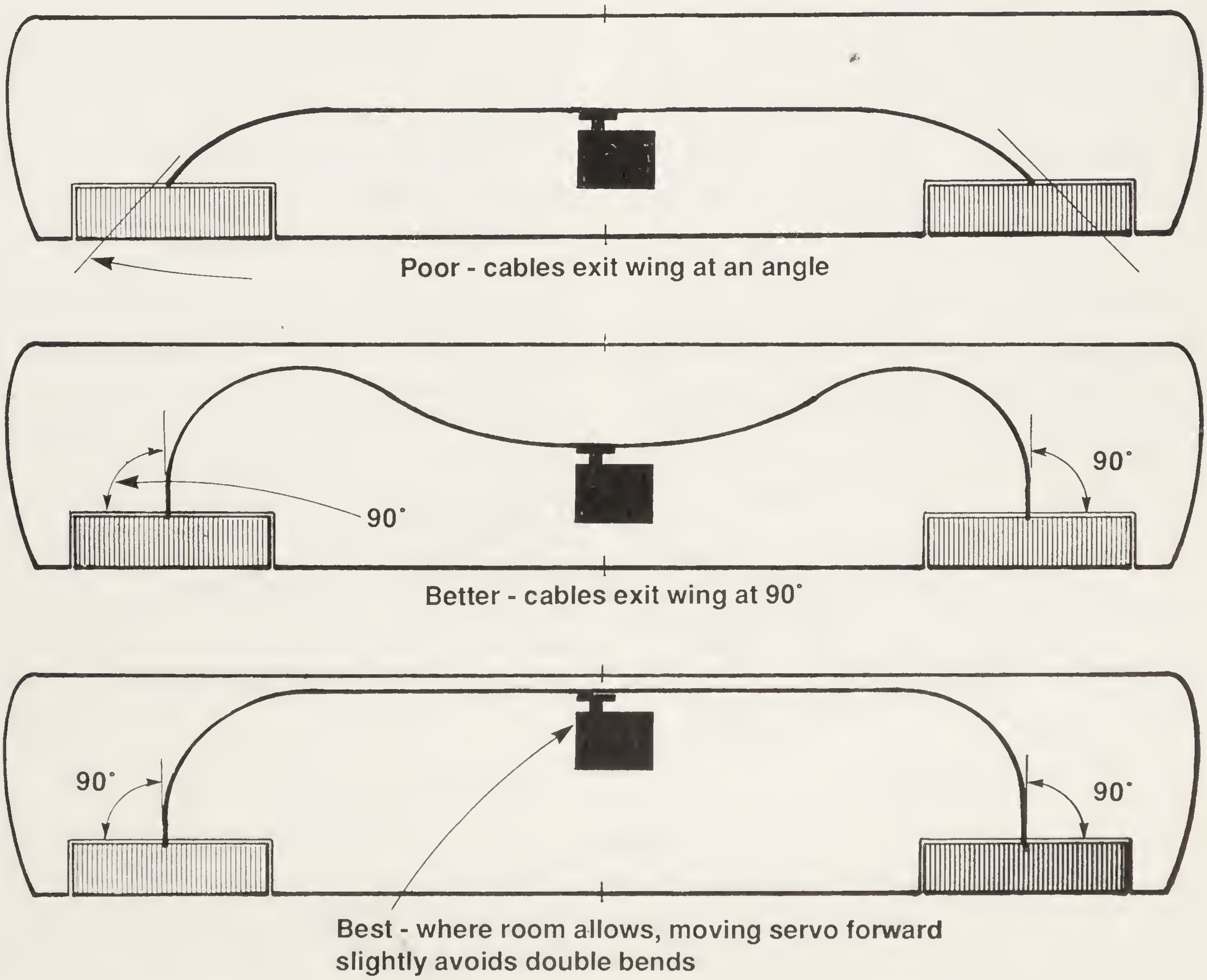
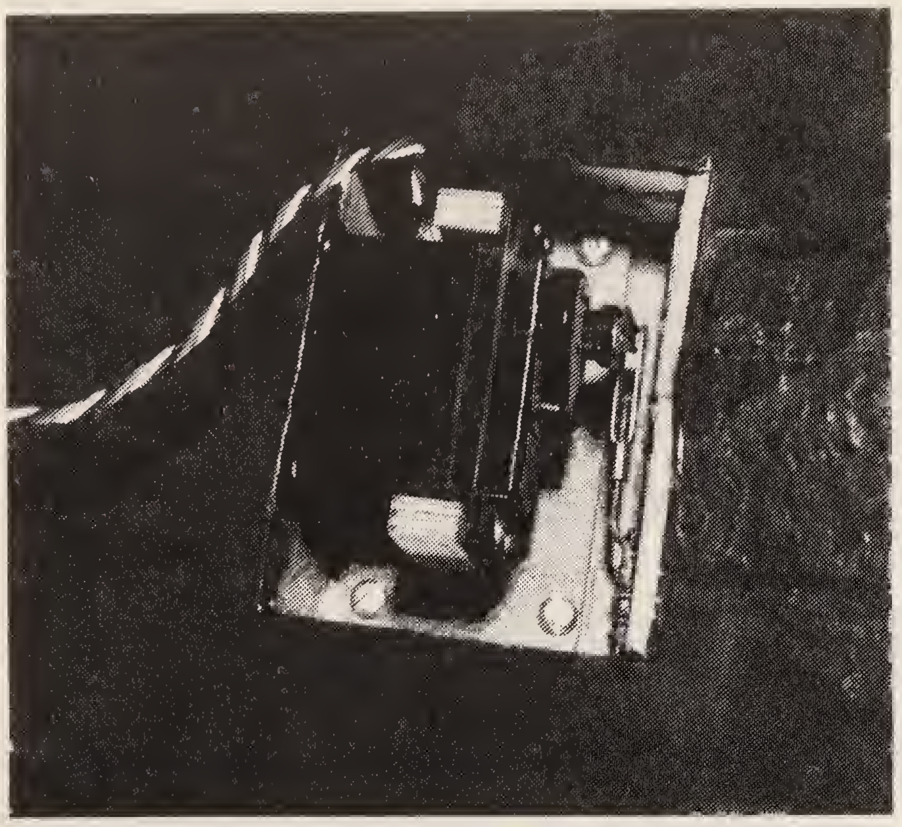
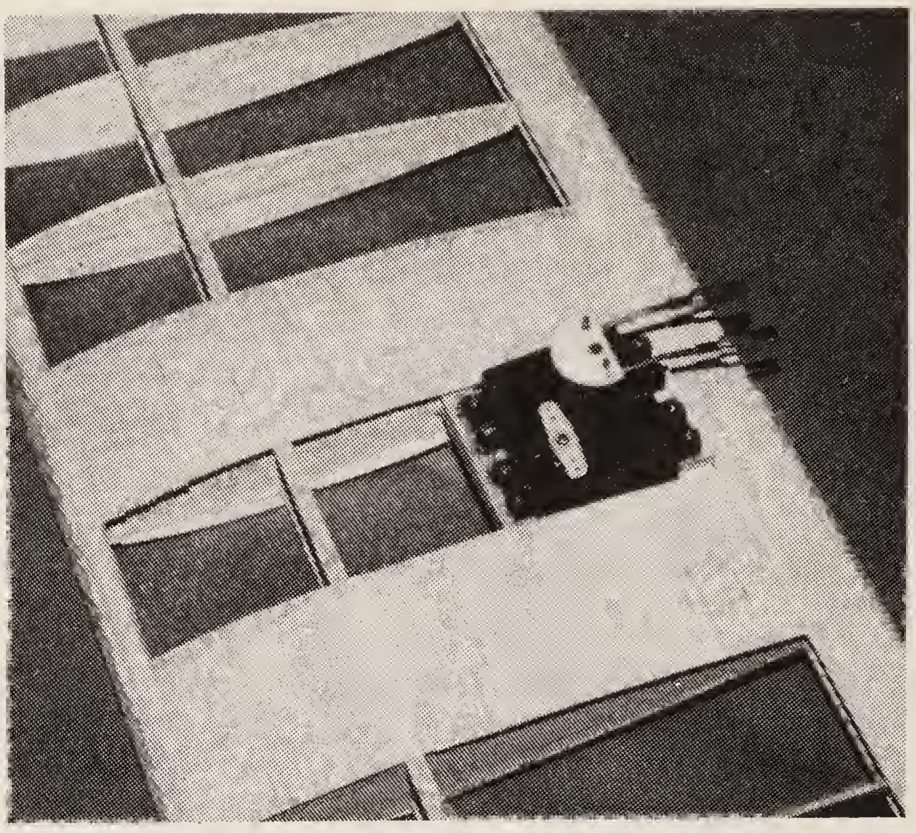


Fig. 4.8 Keep cable curves to a minimum commensurate with 90° horn alignment.



Inset ailerons on larger models can each use a microservo buried in the wing as this example.



Aileron servo for strip ailerons mounted in wing centre section together with elevator servo.

Strip Ailerons

Strip ailerons, although theoretically less efficient, provide an easy to fit simple alternative to inset ailerons. The average flyer need not concern himself with this theoretical inefficiency for strip ailerons *are* effective and have proved popular in many types of competition aeroplanes.

Strip ailerons are best made from semi-hard, straight grained balsa and it is important to select balsa carefully. Balsa which is bowed must be rejected even if this came as part of a kit. Bowed balsa will result in large gaps between aileron and wing. As strip ailerons have a longer gap than insets and that gap, as a percentage of the aileron chord, is greater, every effort must be made to keep the gap to an absolute minimum. Bowed balsa is not a good way to start that process so select with care.

The aileron is connected to the servo via a torque rod and horn assembly. Purpose-made items are available and for smaller models a cycle spoke and modified clevis provide a cheap alternative. It is important that the torque rod is

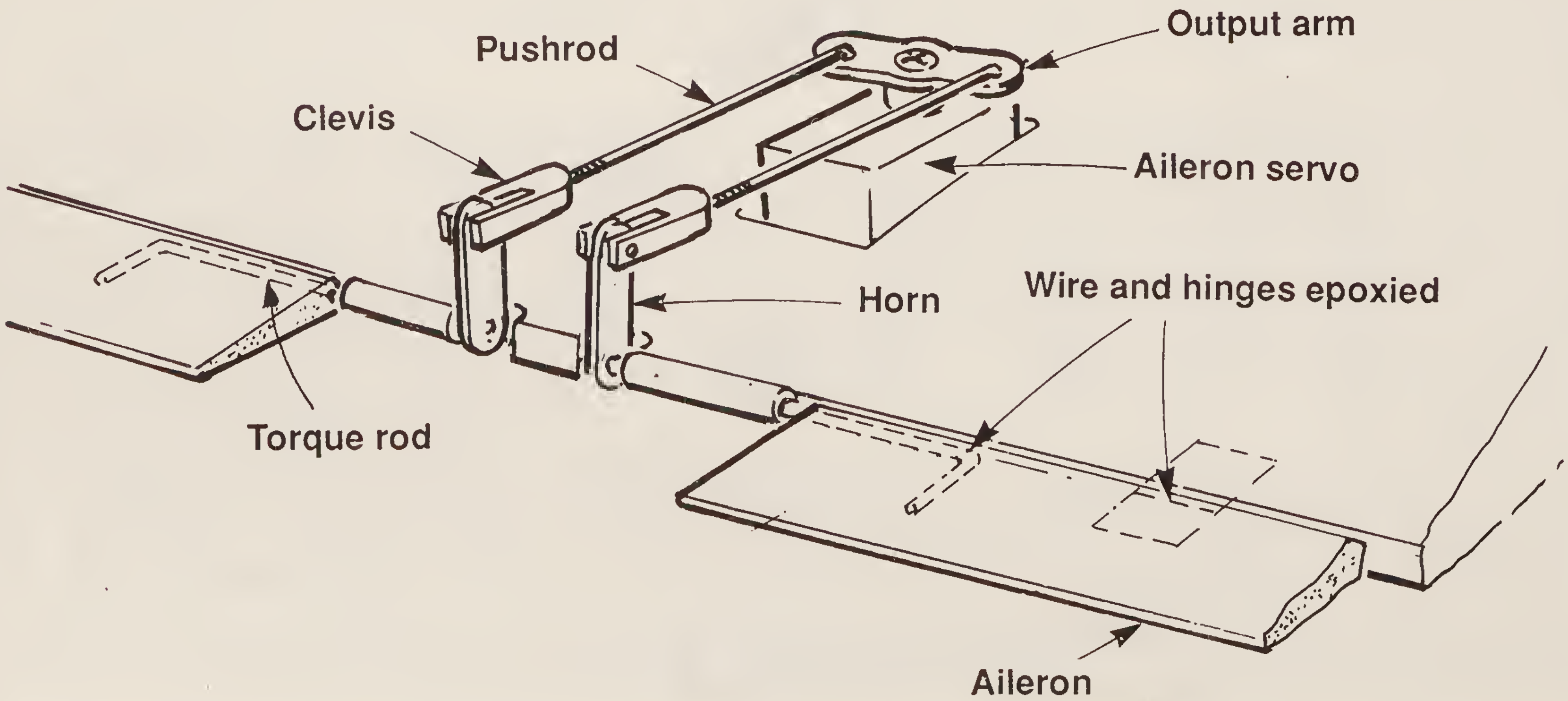
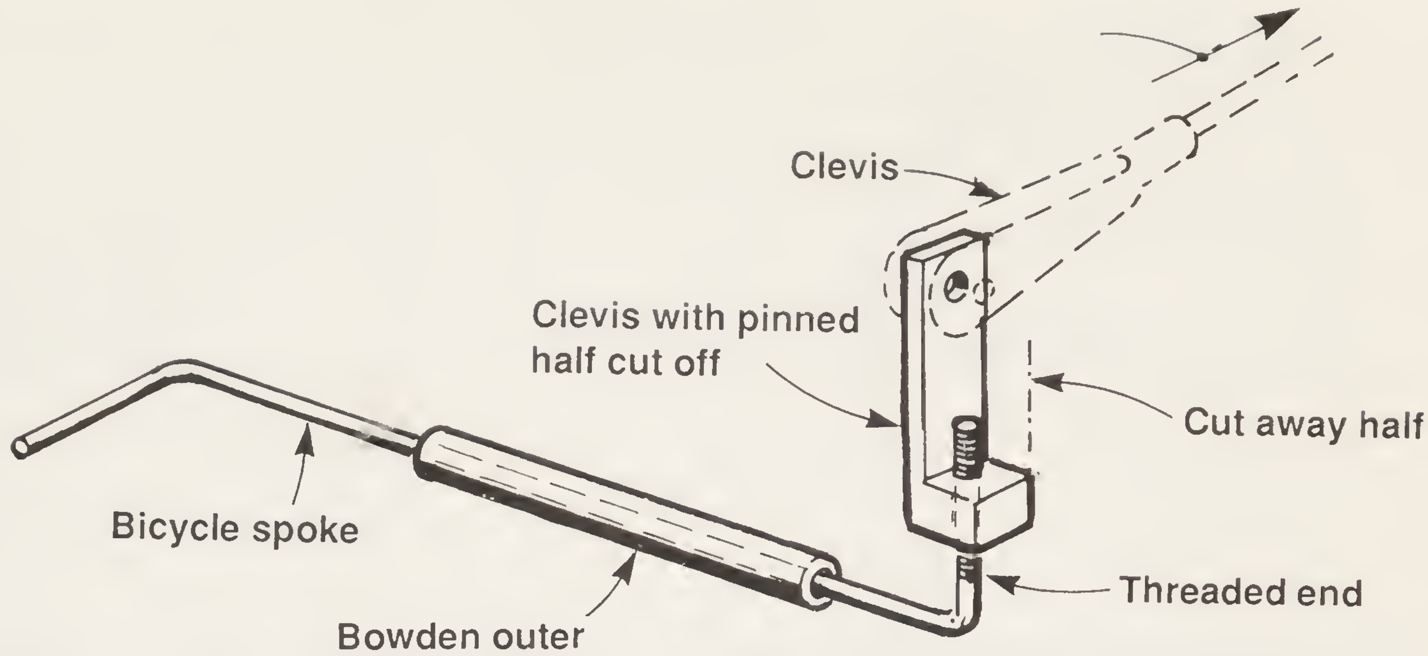


Fig. 4.9 Arrangement of linkage for strip ailerons. Torque rods run in tubes fixed to wing trailing edge.

Fig. 4.10 Simple home-made torque rod and horn. Cut-off clevis can be screwed up or down to adjust aileron movement.



rigid enough for the job; a weak rod will allow the aileron to blow back in flight and control effectiveness will be lost.

Note that the rod runs in a *plastic* tube. Metal tubing, whilst providing a better bearing surface, may also introduce metal-to-metal 'noise' and consequentially radio interference into the system and is better avoided. The torque tube must be firmly secured to the wing. Often it is buried inside the trailing edge but where it is mounted externally, binding in place with cord and epoxy or, on foam wings, securing with small pieces of glass fibre matting is required. Unlike inset ailerons there is no means of reversing the action. The chosen servo must suit the installation. If the installation is for a high wing model (servo and linkage under the wing) a servo which turns clockwise when the stick is moved to the right is required. If the model is a low wing design (servo and linkage on top of the wing), a servo which turns anti-clockwise when the stick is moved to the right will be needed.

Differentials

In the section on inset ailerons we looked at ways of obtaining aileron differential and why we needed it. The need is just as great with strip ailerons but the method differs. With strip ailerons we arrange for the control rods at the servo to be "offset" as shown in the diagram. This offset position causes the pushrod to travel more in one direction than the other.

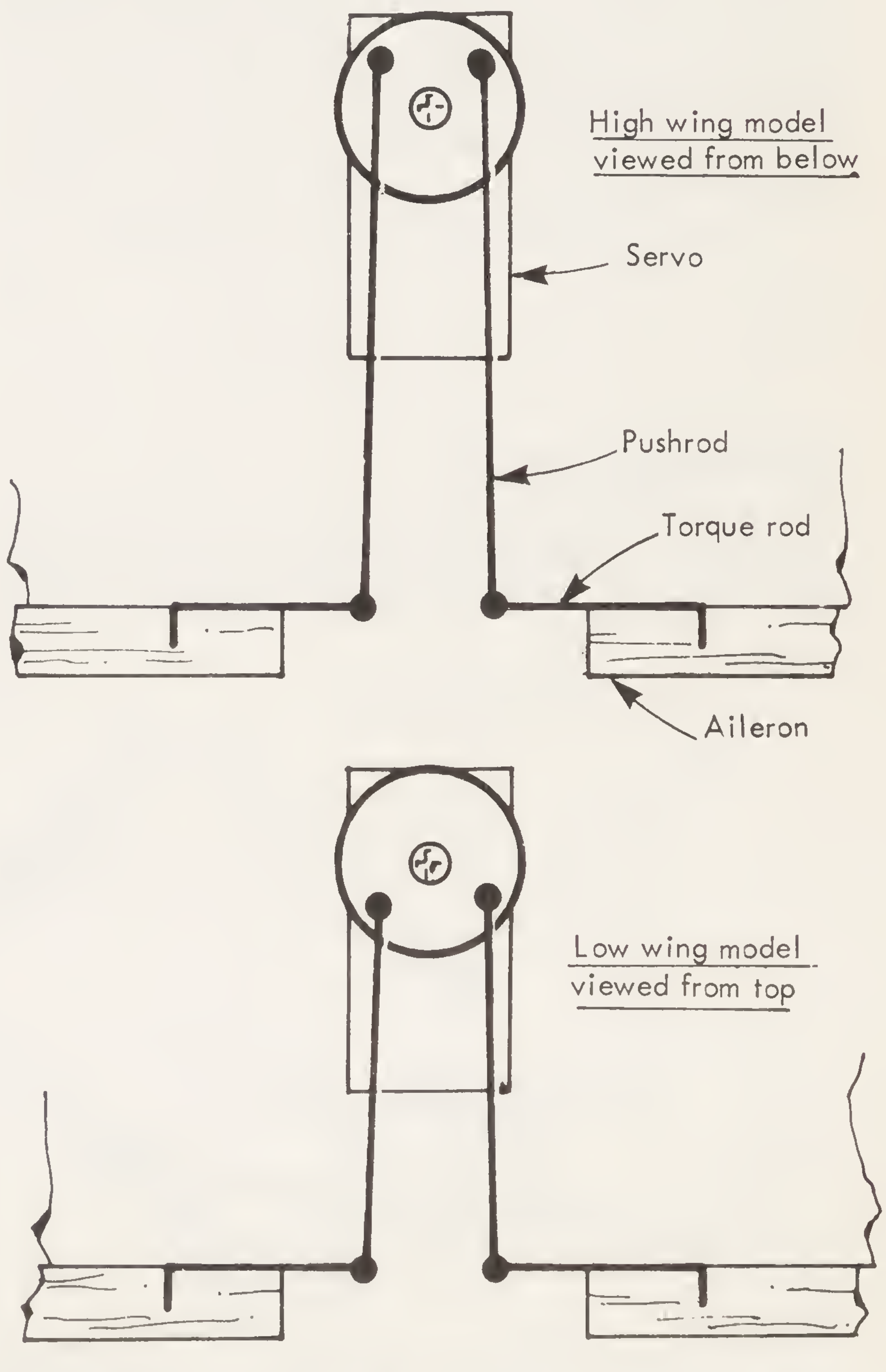


Fig. 4.11 Servo offset for high and low wings.

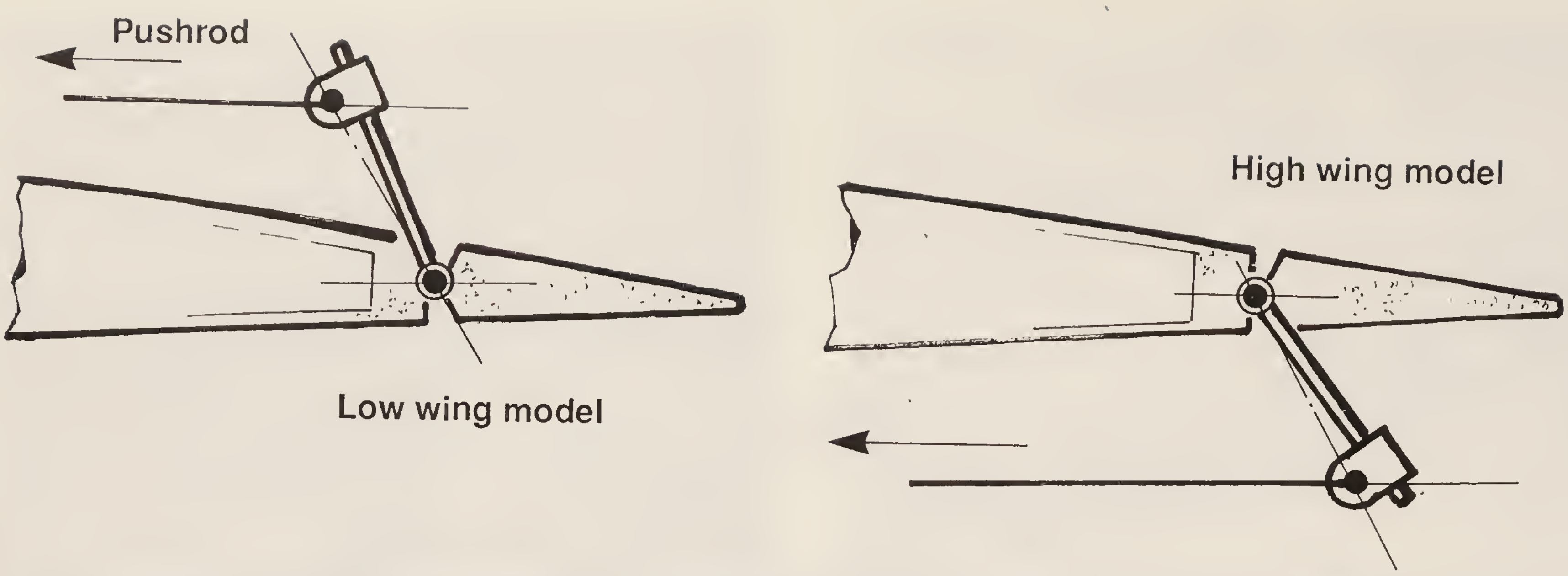


Fig. 4.12 Bending the torque rod forward or backward produces the same result as a raked horn.

A second method follows the principle we used with inset ailerons of raking the aileron horn forward or backwards. The required angles can be bent into the torque rod and the same principle applies. Raking the torque rod arm forward on a low wing model will give the desirable more up than down. Conversely, on a high wing model, the arm should be bent backwards.

Sealing the Gaps

We have already referred to the need to keep the gap between aileron and wing to a minimum. This is possibly more important on strip ailerons where any gap, even a tiny one, will, compared with inset ailerons, be a fair percentage of the aileron chord. Up to 30% of effective aileron response could be lost with big gaps. Such gaps allow excessive bleeding of air from the high pressure area beneath the wing to the low pressure area above the wing. Many full-size light aircraft use fabric seals to prevent this bleeding. On models plastic film covering or 'garden quality' adhesive tape can be used with great effect. It's tricky to apply and it must not stiffen up the action unduly but properly applied is very effective.

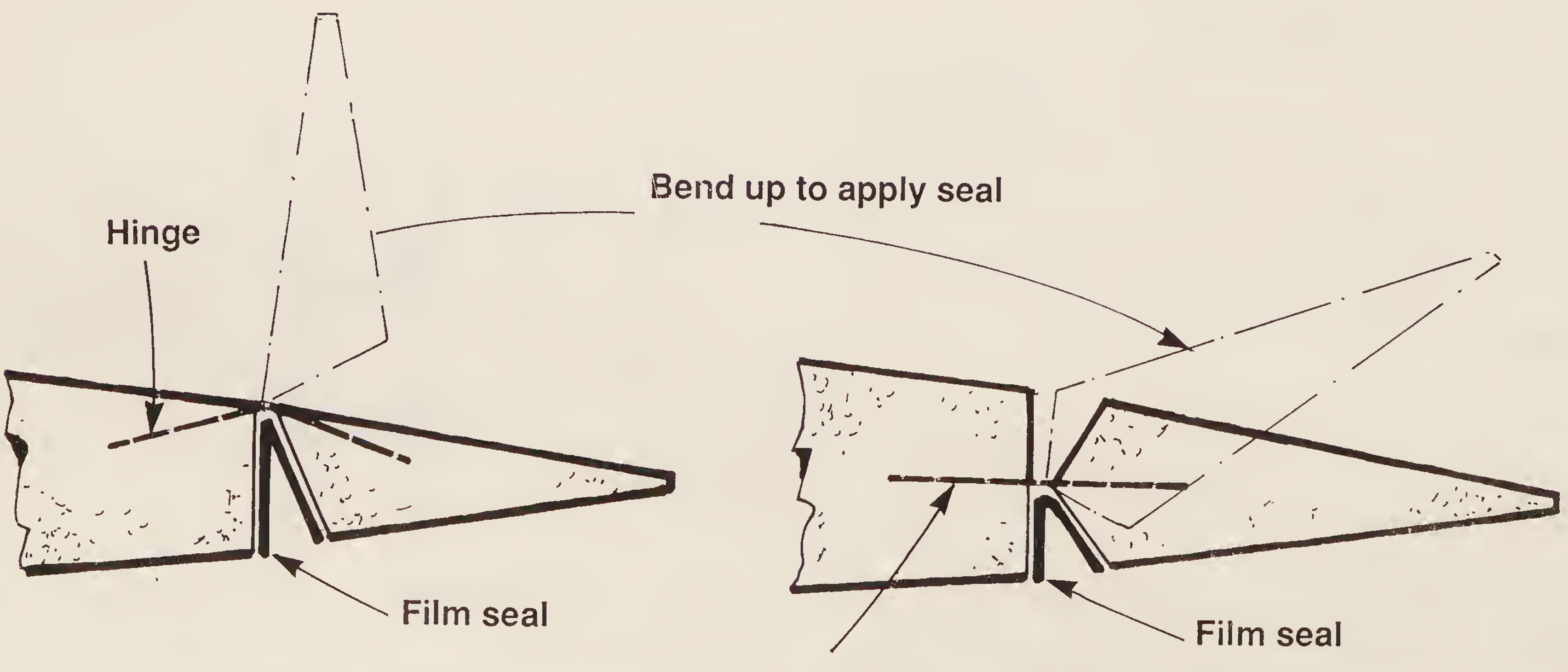


Fig. 4.13 Plastic film seal applied to inset or strip ailerons. The apex of the seal should be as close as possible to the hinge line.

Chapter 5
Mixing

SO FAR we have discussed radio installation in conventional models where rudder, elevator, flap or ailerons have been the order of the day. However, less conventional models often require mixed functions. For example a 'V' tail model in the absence of separate elevator and rudder surfaces will require these functions to be mixed to provide both pitch and yaw control via the 'V' tail. Tailless models, or indeed some high performance aircraft with tails, often feature flaperons—a mixing, as the name implies, of ailerons and flaps to provide roll and pitch control from one surface.

Electronic Mixing

Electronic mixing is often an integral facility of the modern R/C system. All that's required is the operation of a switch in the back of the transmitter and the two functions are automatically mixed. The amount of mixing is adjusted by a small 'pot' also in the back of the transmitter, an easy task allowing on-field trimming between flights. The servo arrangement for such a system is shown in 5.2d and there are few pitfalls. The system is simple enough and requires two fixed servos. As well as the ease of adjustment this system enjoys an element of failsafe; if one servo stops

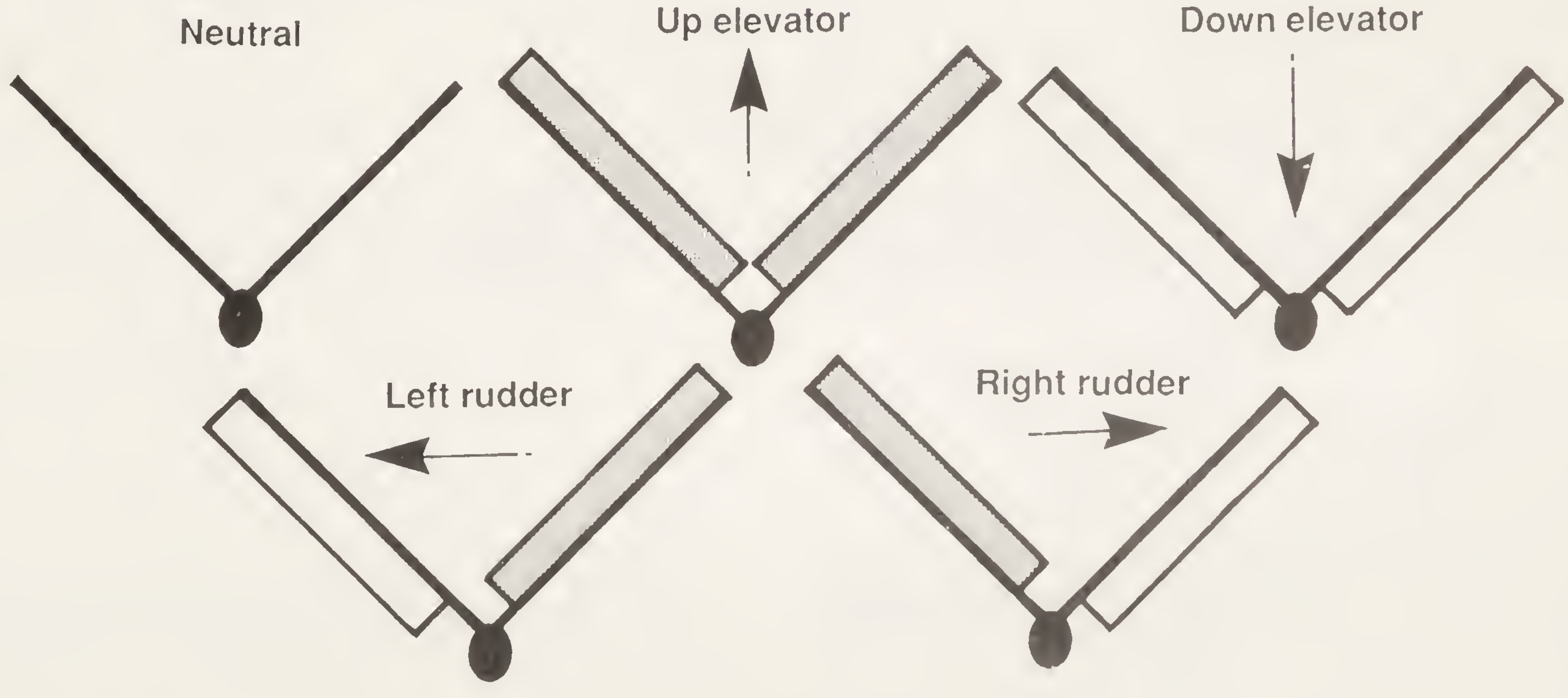


Fig. 5.1 Mixing requirements for rudder and elevator on a V-tail model.

working the remaining servo will retain some authority and the pilot some control.

Add-on electronic mixers

These are the alternative electronic mixing systems where the available radio equipment does not allow mixing. The input into the mixer is the outputs from the Rx that require mixing. The mixed outputs are usually adjusted by 'pots' accessible through the side of the mixer case. Although the advent of "in house" mixing on most R/C systems has lessened the need for add-on electronic mixers, a few specialist manufacturers are still able to supply and are best found via the classified advertisements in the modelling magazines.

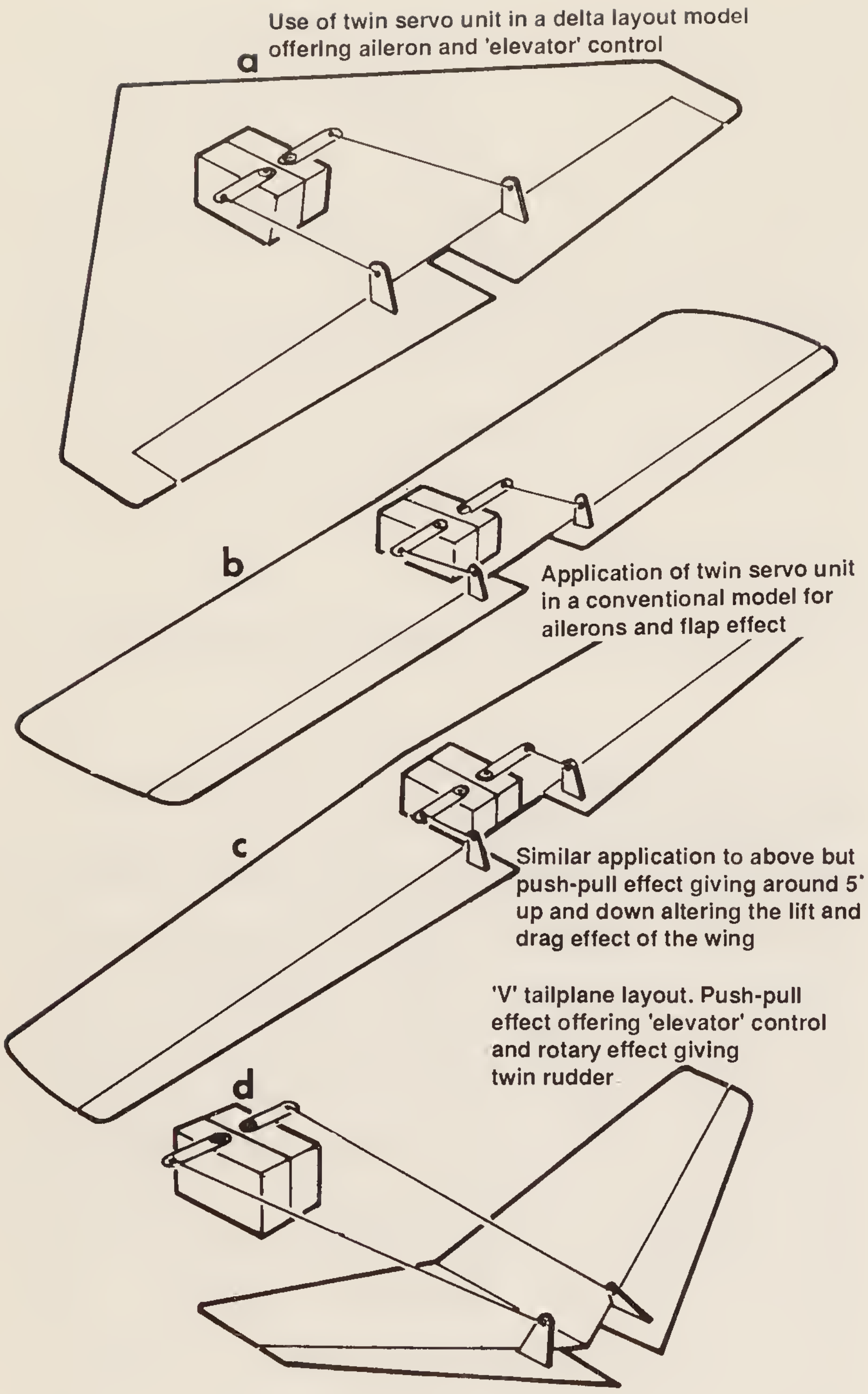


Fig. 5.2

These illustrations show uses for twin servos with or without additional slave servos. Other applications will no doubt come to mind.

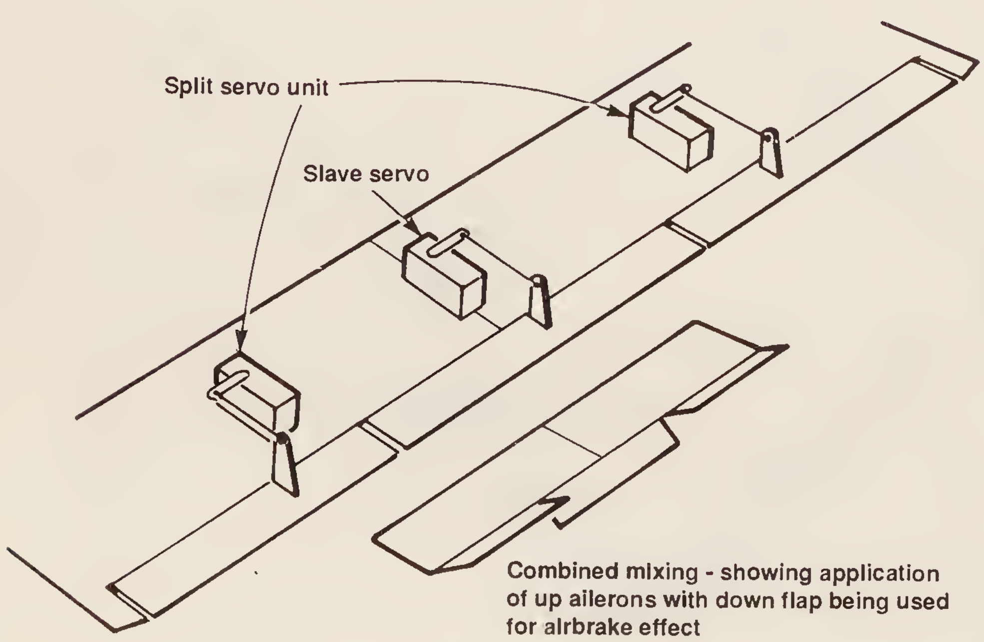


Fig. 5.3

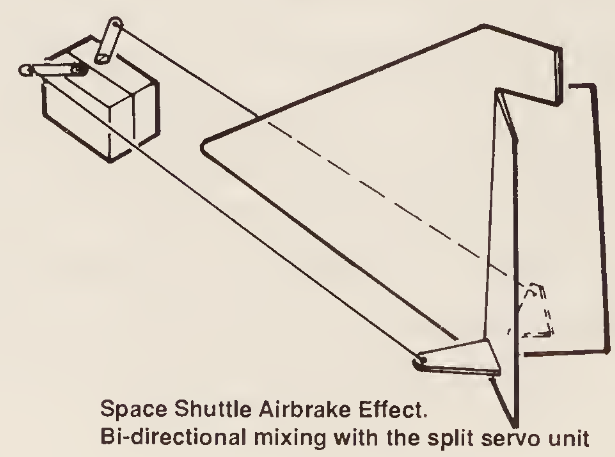


Fig. 5.4

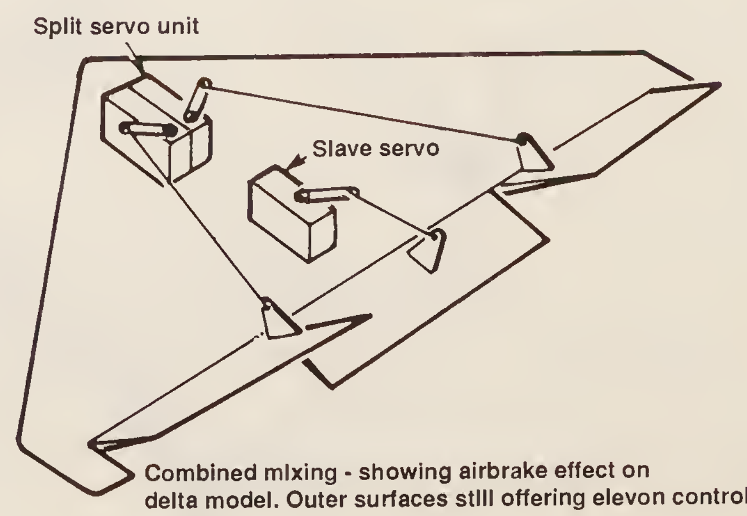


Fig. 5.5

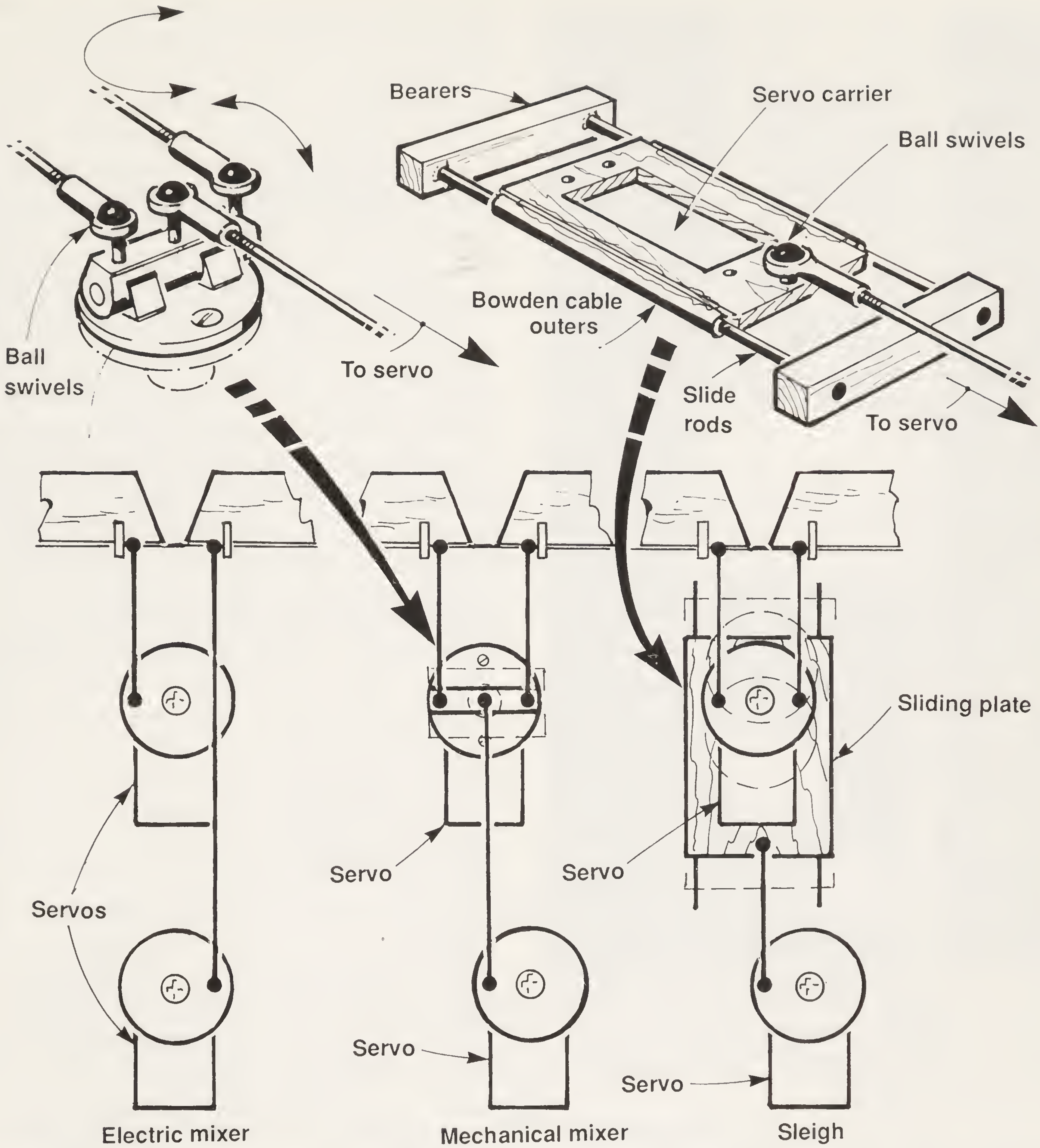
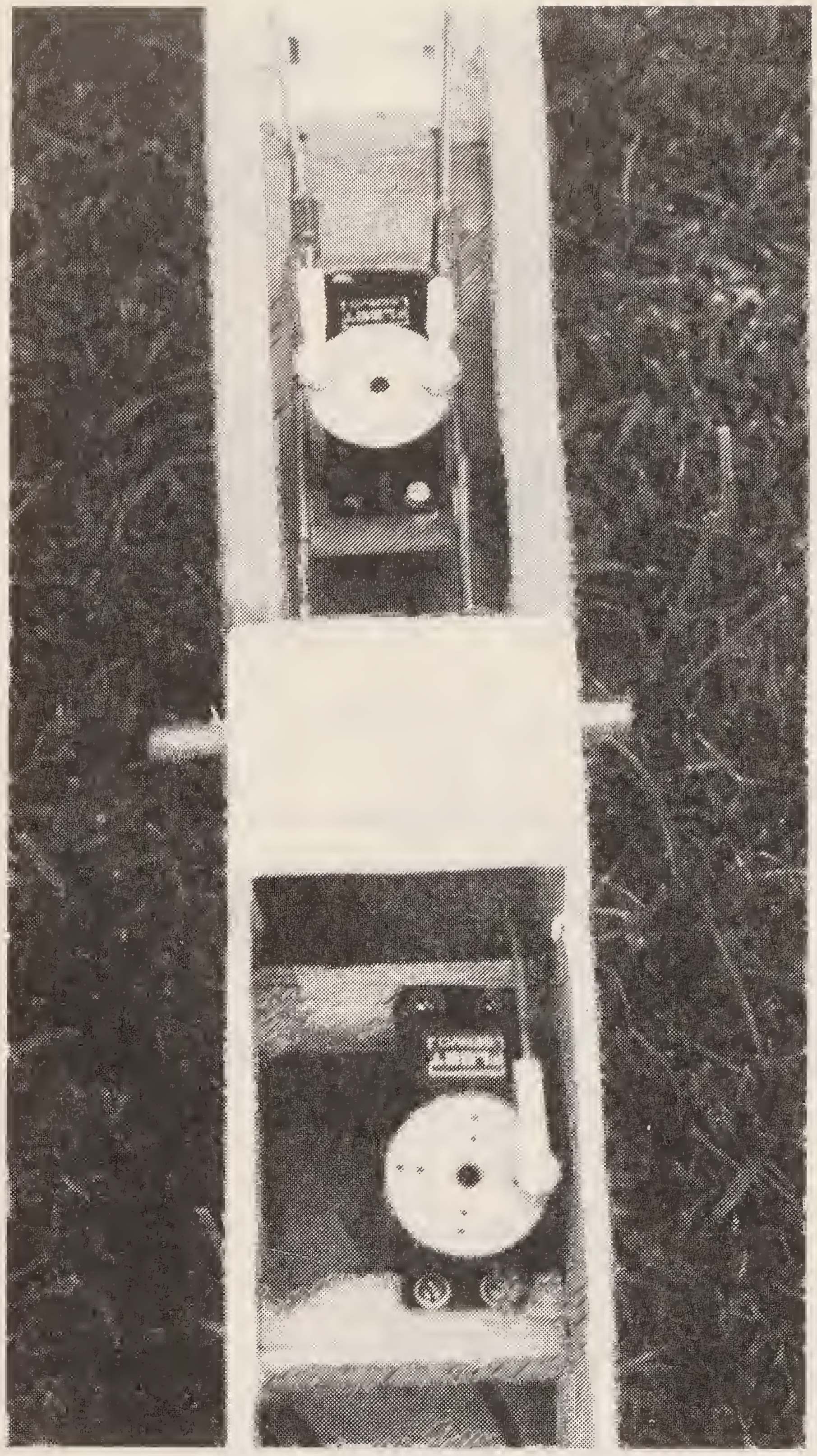


Fig. 5.6 Further uses of twin servos. Note the centre arrangement employs a rocking arm and thus ball connectors are essential for it to work without slop. The sliding sleigh mechanism should also be slop-free.

Mechanical Mixers

Mechanical mixing was the original, and some would argue the best, way of providing mixing. Mechanical mixers are certainly the cheapest, being available at little cost from the local model shop or free of charge to those wishing to make their own with items from the scrap box. A home made mixer is shown; the principle is simple enough.

The "rudder" servo is mounted on a tray that is free to slide fore and aft. The sliding tray is connected to the output arm of the "elevator" servo. Thus the rudder servo, acting equally on each "ruddervators" to provide yaw, but the



There are numerous ways of producing mechanical mixing for 'dual purpose' control surfaces i.e. elevons and 'v' tails. The photo above shows a fixed servo for the pitch (elevator) movement and a sliding servo, connected to the elevator servo, for the roll (aileron) control.

elevator servo operates via the sliding rudder servo, acting equally on each control surface to provide pitch control.

Providing space is available and a little attention is paid to ensuring that the sliding tray unit moves freely on the rails, sliding trays provide excellent mixing. If however you prefer to buy your mixer off the shelf then commercial items can be bought; essentially these work on the same principle as the sliding tray but employ a servo-mounted pivot bolted directly onto the servo disc.

Mechanical mixers are easy to install, the servo mounted types requiring little extra space. They do however need careful setting up and balance will be required to get the rudder/elevator ratio (usually about 70/30) right.

Coupled Aileron and Rudder

Some high wing models, for example Piper Cub or Fieseler Storch scale models, are often reluctant to turn with just an application of aileron. The wing layout and aileron design is such that ample amounts of rudder are also required, with the aileron, if smooth turns are to be produced. As with 'V' tail designs the necessary mixing of the functions is often available at the transmitter and again this offers the advantage of adjustment of the mixing ratios. For those with more basic equipment without mixing the necessary effect can be obtained. All that is required is a simple 'Y' lead connecting the aileron output at the receiver to both the aileron and rudder servos.

Chapter 6
Retracts

NOT too many years ago the fitting of a retracting undercarriage to a model was considered stuff for the experts—not to be contemplated by the average. Indeed it was only on scale models and aerobatic competition models that retracts were found—the average sports flyer left them well alone. Yet for most suitable models the advantages of fitting retracts outweigh the disadvantages. With the wheels tucked up models usually fly faster and

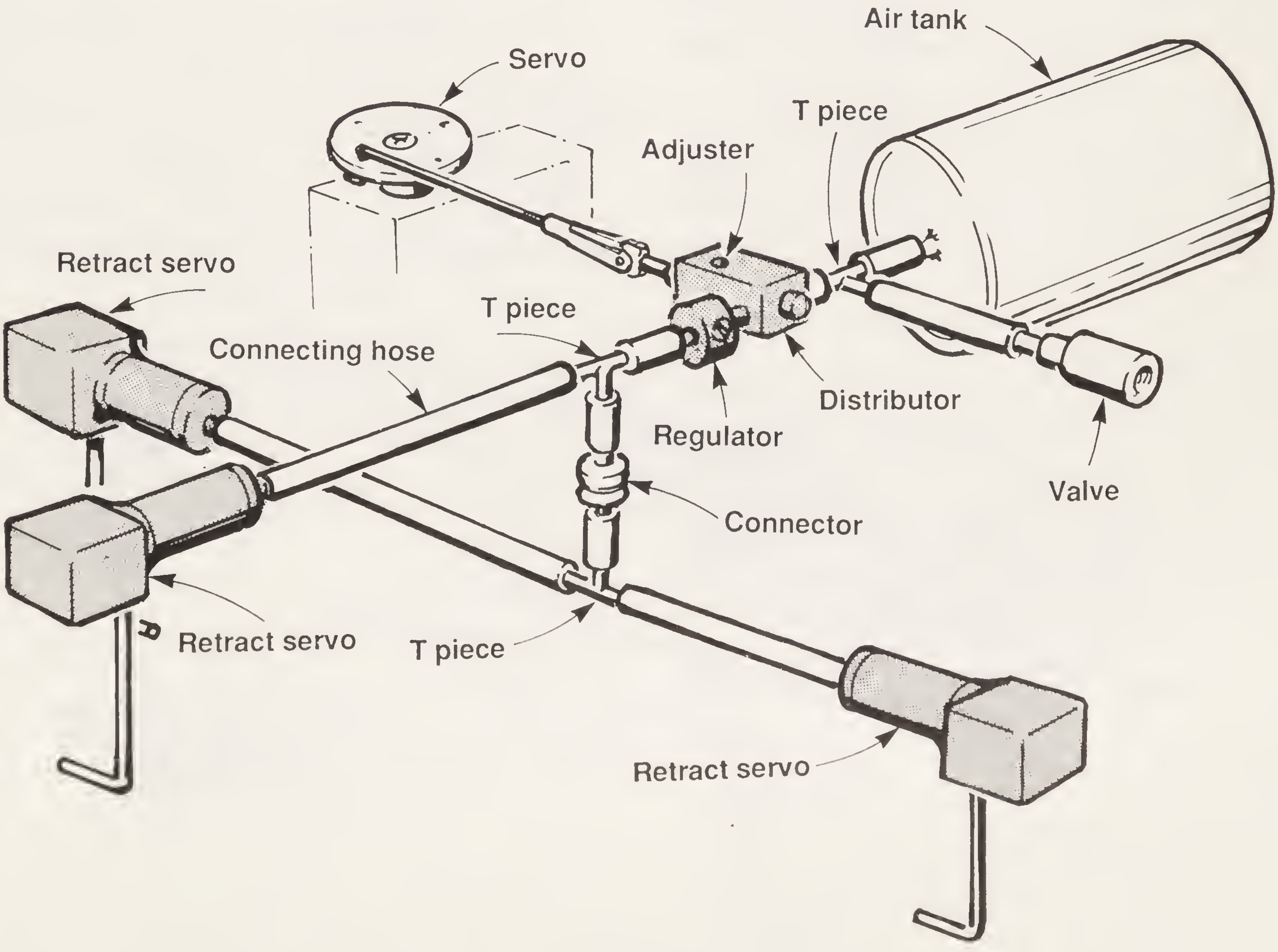


Fig. 6.1 Pneumatic retract system.

smoother. They also tend to look better, and as the enjoyment of flying model aircraft is very much a visual perception then retracts are often money well spent.

Retracts are available in two different types. The pneumatic type operates on compressed gas. The gas is loaded into a reservoir before each flight and sufficient gas is stored to allow sufficient complete cycles of the system for the flight. The reservoir is connected via a pneumatic valve by small diameter plastic tubing to each leg assembly. This consists of a cylinder and piston arrangement, the piston being connected to the leg operating mechanism. A servo is required to activate the pneumatic valve which allows gas through to the cylinder to move the piston and with it the undercarriage leg.

Pneumatic systems tend to be more expensive than mechanical types. However, the big advantage of pneumatic systems comes from their ease of installation. The plastic tubes are small and flexible and easily built into a wing structure. Tortuous wire bending is not required and just one standard servo will operate the valve. The only disadvantage of pneumatic systems is a vulnerability to leaks, although the modern majority are designed to fail-safe. No gas or air and the legs extend, the weight of the wheels and a powerful spring providing the driving force.

Mechanical Retracts

Mechanical retracts are usually cheaper but more difficult to install. Each leg requires servo operation and consequentially some fairly accurate wire-bending to boot. However, with care and patience satisfactory systems are possible. Special retract servos are available. These are higher power, usually slower in operation and operate over a greater arc than their conventional counterparts.

Most mechanical retract designs use the system shown below and whilst some may also use a balance spring to take the weight of the wheel the basic principle remains the same.

Planning the installation should take place before model building commences

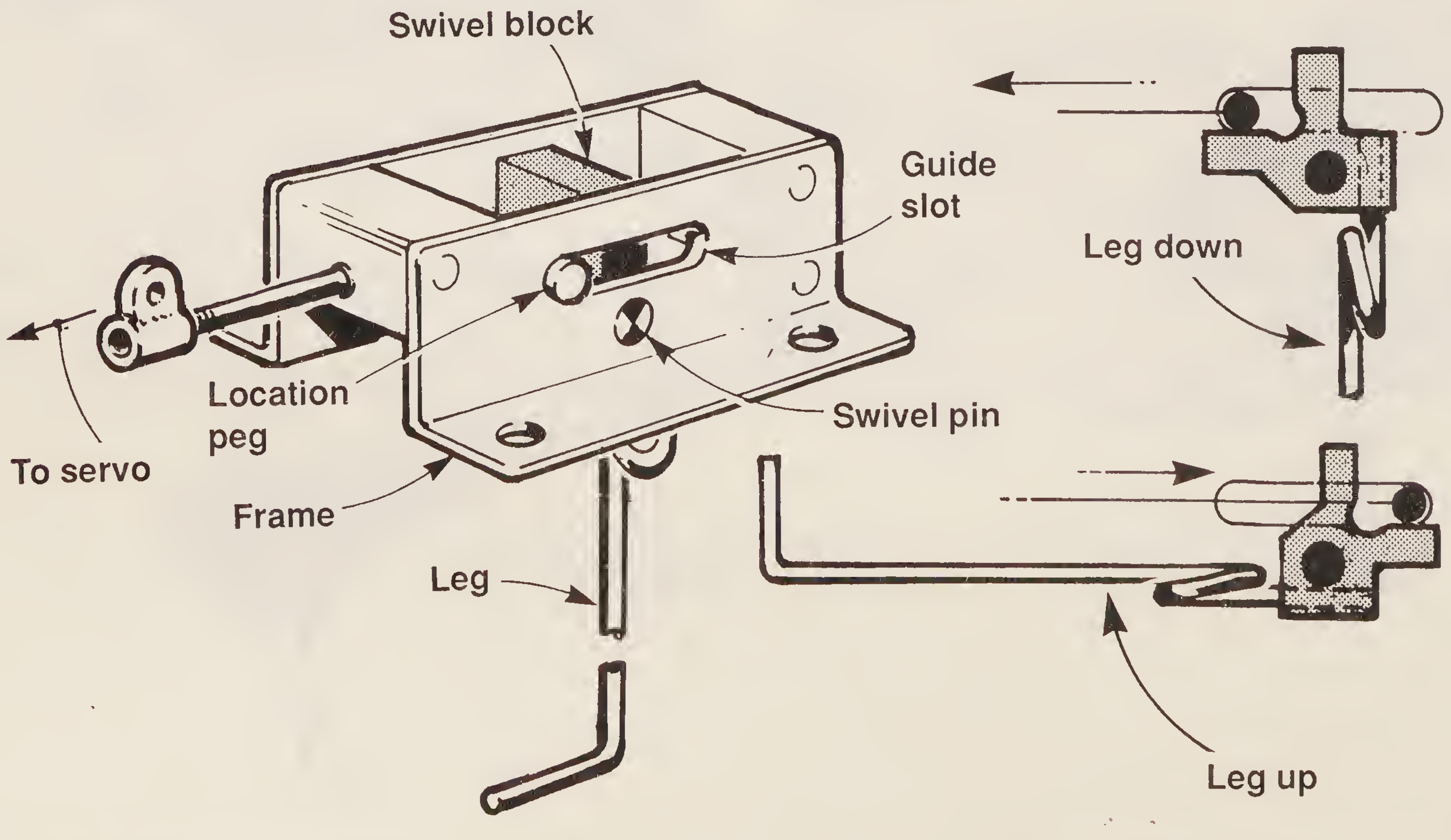
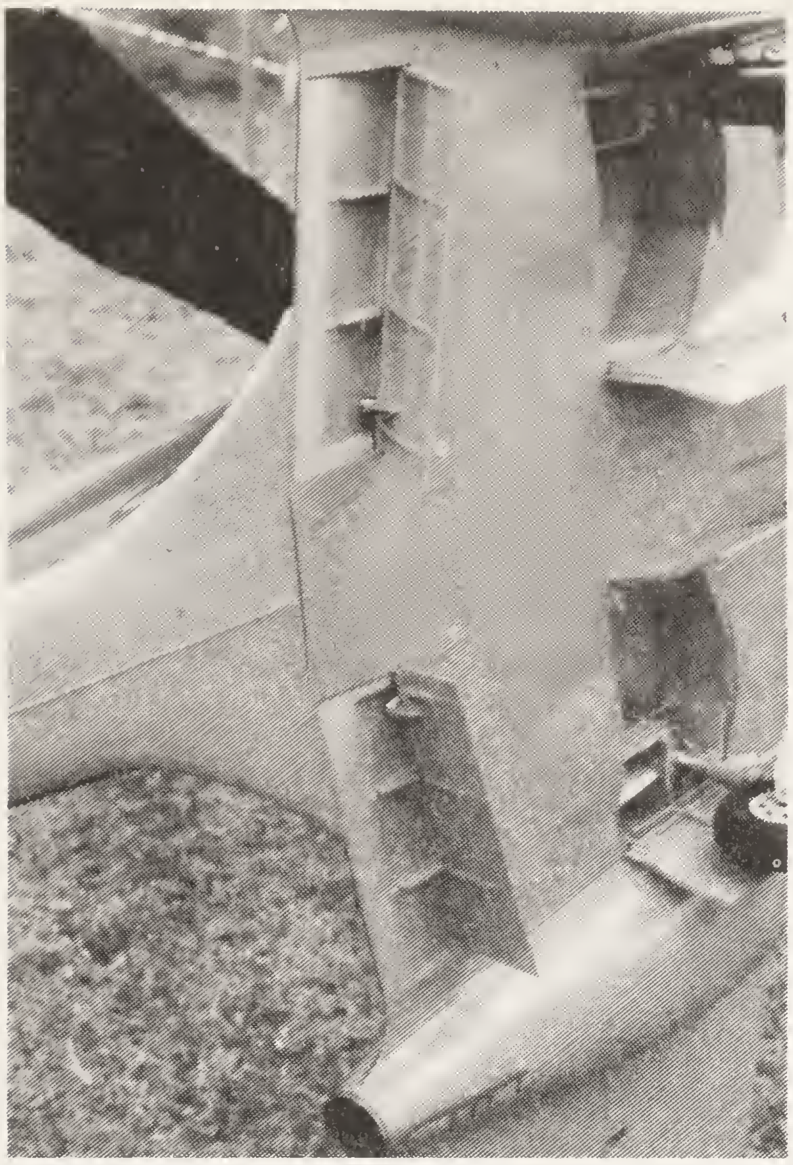
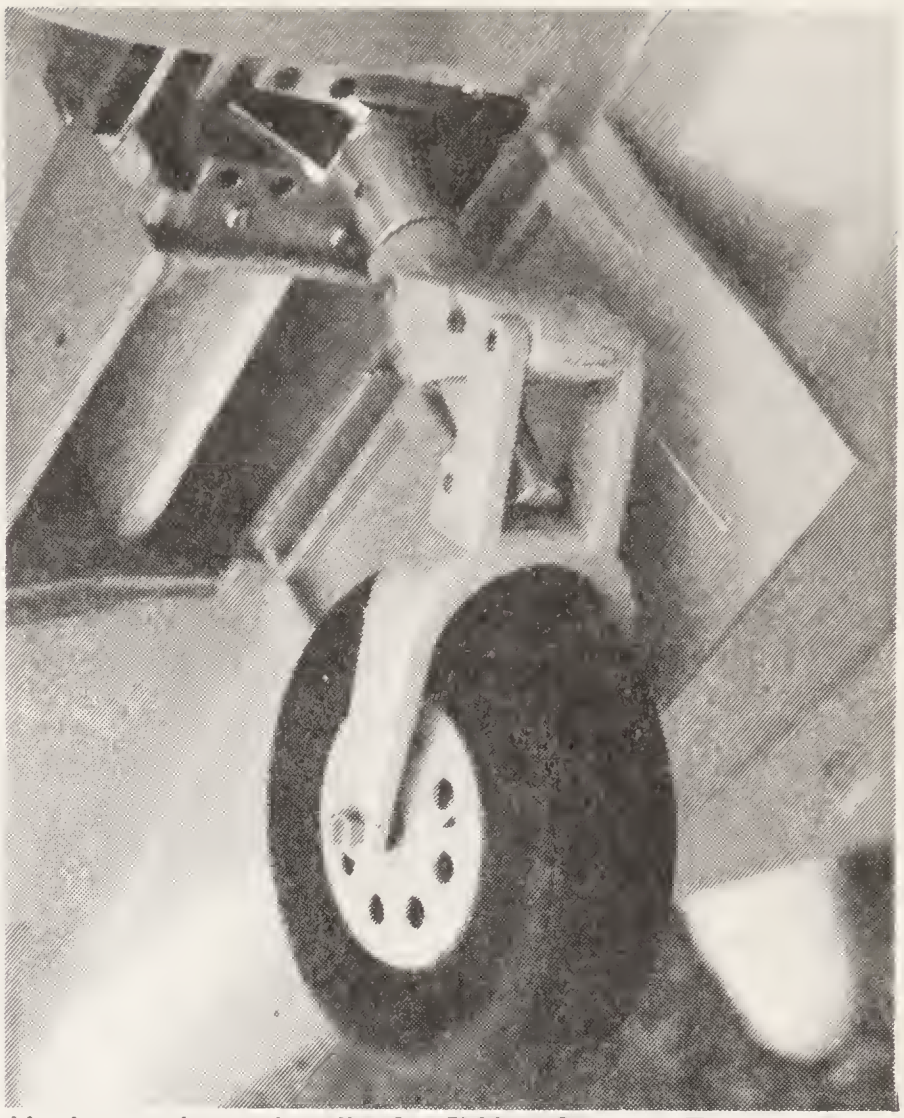


Fig. 6.2 Mechanical leg operation.





Undercarriage detail of a 76in. Gloster Trent (airscrew) Meteor by David Toyer. Weighs 18lbs.

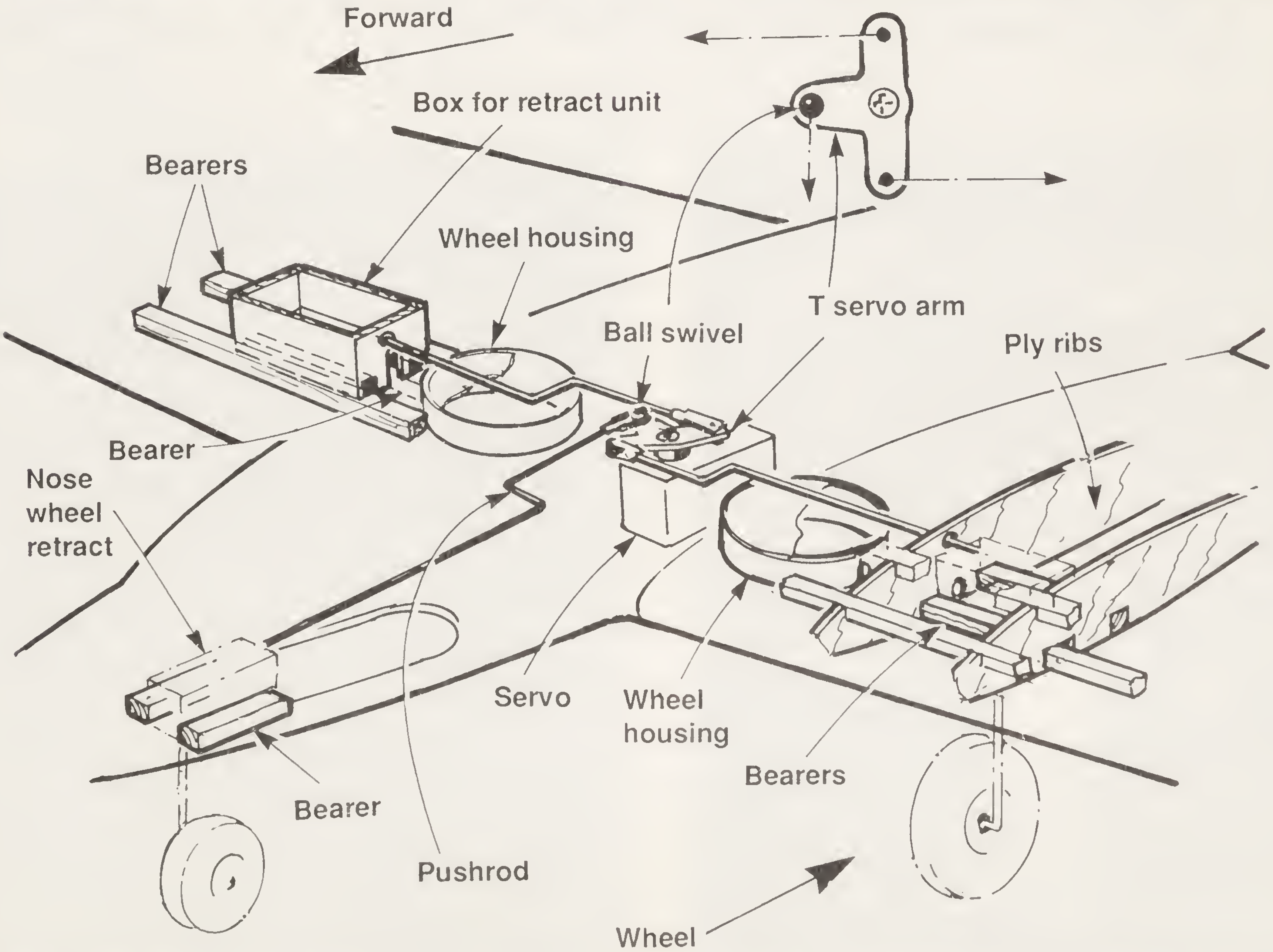


Fig. 6.3 Three legs from one servo—not recommended but possible with patience and wire-bending skill.

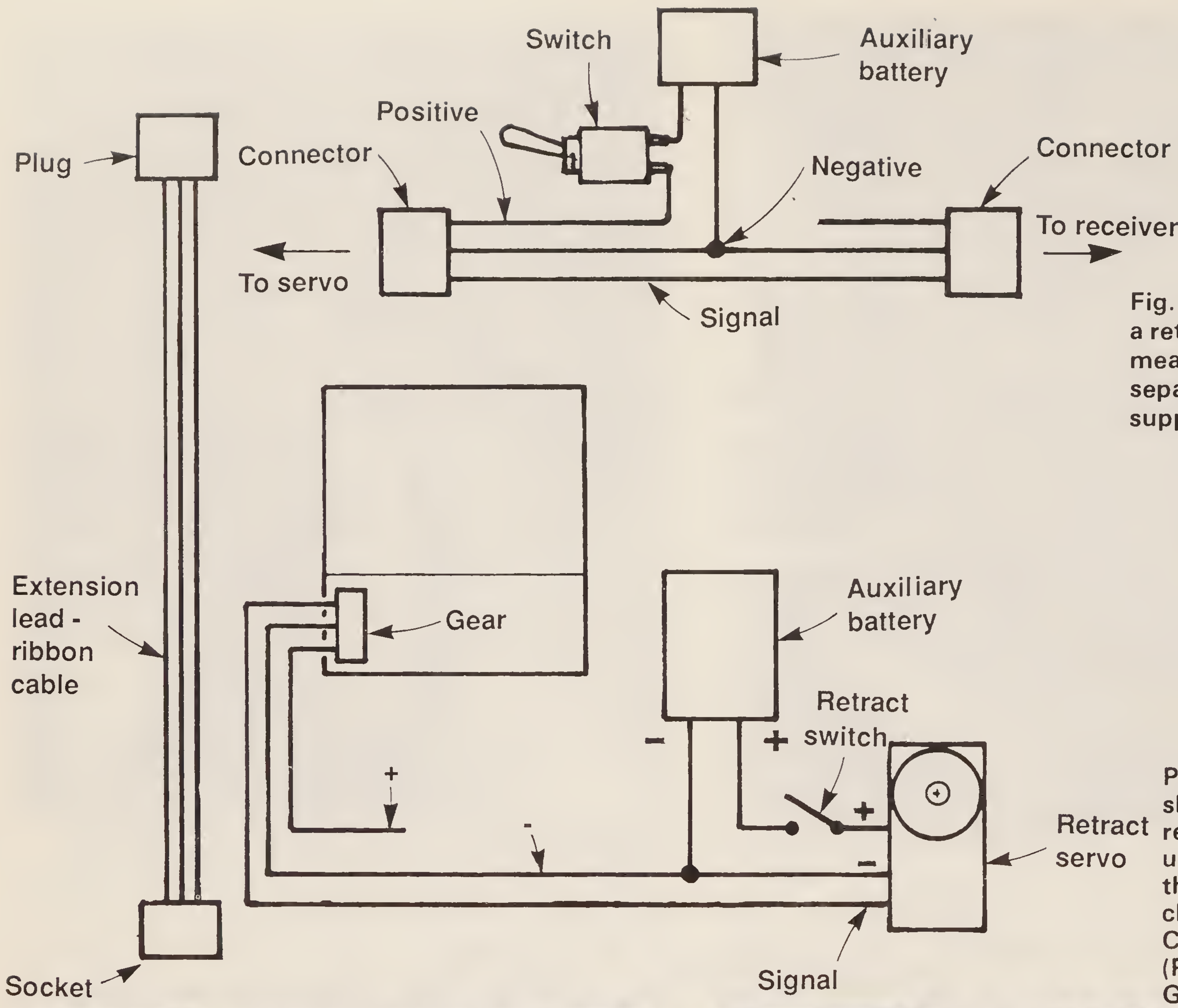
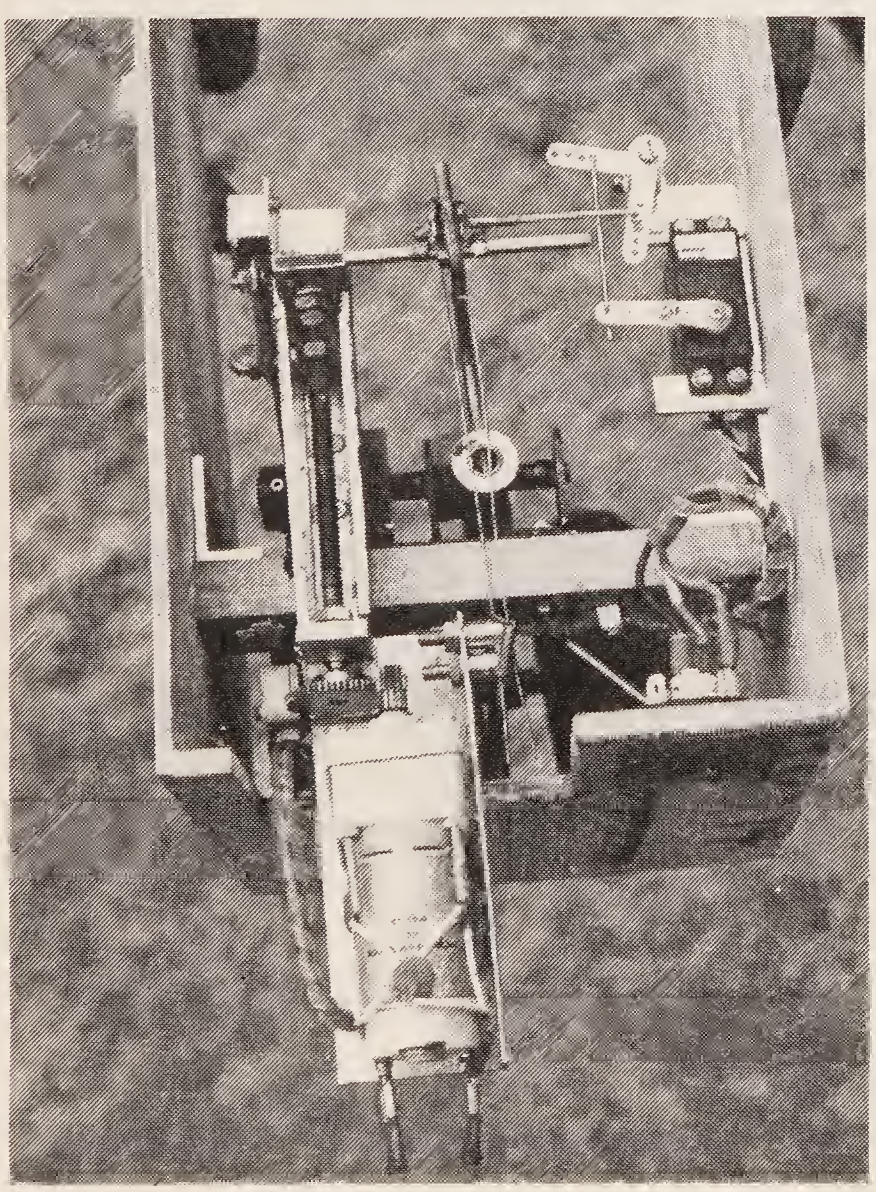
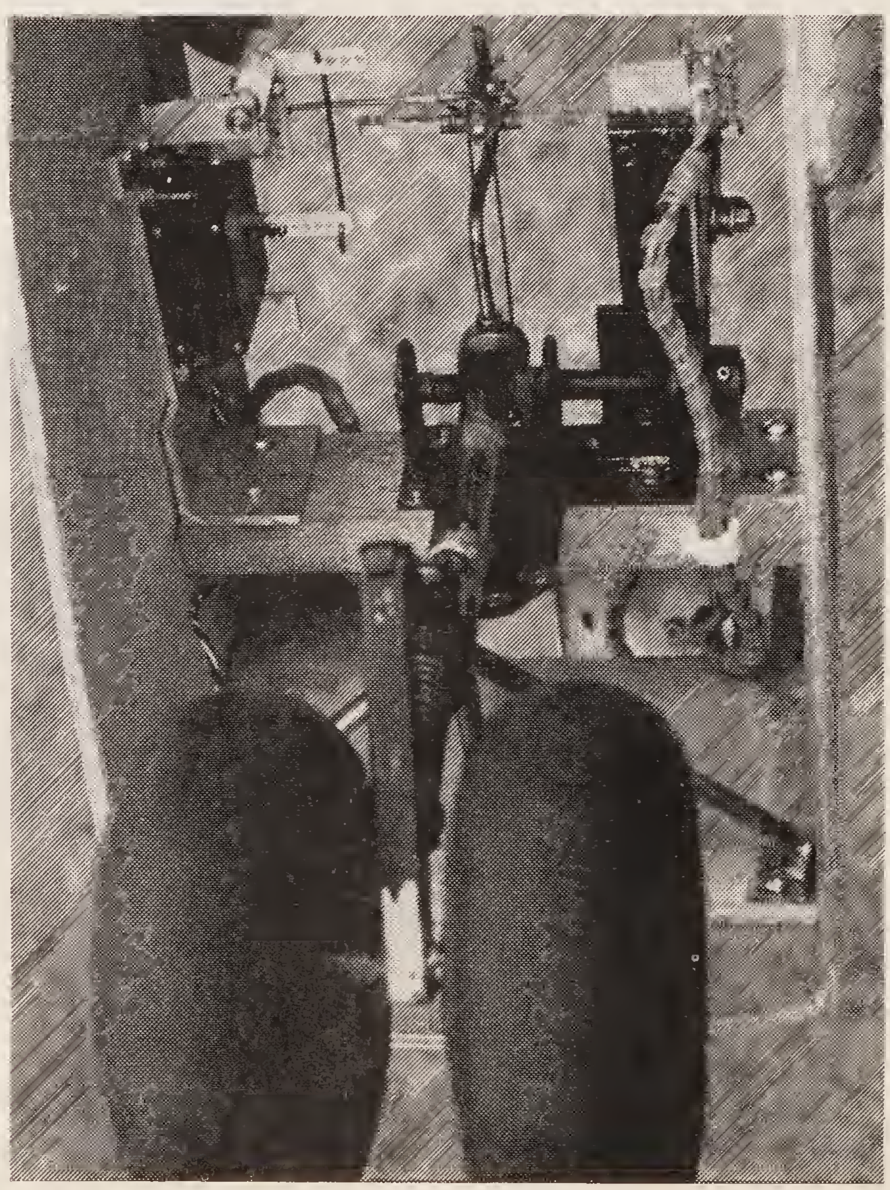


Fig. 6.4 Powering a retract system by means of a separate power supply.

Photos below show a massive retracting undercarriage on the Warrington club's 19 ft span C130 Hercules. (Photos Brian Gowland).





and my own approach has been to photocopy the relevant parts of the plan and then draw the retract installation, showing pushrod runs and servo locations, onto the photocopies.

It is possible to operate all three legs from one retract servo; however, the ease of installation seems roughly proportional to the number of servos used and a servo for each leg makes life much easier. Where a servo is used for each leg it can be mounted close to the leg, keeping pushrod runs very short. Long 'Y' leads will be required and these should be built into the wing. Of course, three servos for three legs is expensive unless you happen to have servos lying around doing nothing. A satisfactory compromise comes by using two servos, one in the wing for the main legs and one in the fuselage for the noseleg. Thus complicated pushrod hookups are avoided, but the cost of the servos is limited to two.

As with all servo installations it is vital that the linkage is arranged to allow the servo arm to reach the end of its travel. Any baulking or binding will increase the current draw by the servo dramatically and flat batteries are a certainty. It's also possible for the servo to be stalled by the gear not retracting properly. A leg bent out of line by a previous hard landing will stop a wheel from fully retracting into its well, stalling the servo. Again, flat batteries are likely and the prudent modeller must consider the advantage of powering his retracts from a separate airborne battery pack. It's not too difficult to arrange, and some of the manufacturers we spoke to said they would make up suitable wiring harnesses if asked.

All that is required is a servo extension lead and a switch. The principle of the arrangement is to intercept the positive wire from the receiver to the servo and cut it. A new positive from the auxiliary battery is connected to the servo via a switch. The negative from the auxiliary battery is connected into the existing negative lead. The signal wire is left untouched. This arrangement means that although the information about the servo position comes from the receiver, the power to drive the servo now comes from the auxiliary battery, not the main. Any hangups will flatten the auxiliary battery leaving the integrity of the airborne system protected.

Chapter 7
Electric Power—Motor Control

IN THE EARLY 80s I was asked to demonstrate the Acoms electric Cessna at various model shows. This was a major change from my current R/C activity of the time—pylon racing—and I accepted readily. Those little all-foam Cessna were my second excursion into electric flying as I had been flying an early kit model (MFA Hummingbird) very successfully some years before.

In those early days both the Cessna and the Hummingbird shared one common failing; there was no way of turning the electric motor off via the radio link. The motor was turned on and off via a switch mounted on the side of the fuselage and that was it. Once airborne only a crash landing or battery exhaustion was going to bring the model down. As the battery became exhausted the model became reluctant to fly. Yet with some residual power being produced by the motor it was also reluctant to land. Even in very calm weather that in-between state was uncomfortable and the consequent arrivals did nothing to ensure the survival of the propeller or longevity of the airframe.

Today, the electric flier has a choice of commercial unit or home crafted devices, and even those overweight "unlikely to fly" plastic devices which are aimed at the 'toy end' of the model market have ways of stopping the motor.

Mechanical Switches

All that is required, after all, is a small lightweight switch operated by a small servo. Micro switches are the answer and suitable products are available from electronic components stockists. Current rating doesn't seem too important and reliable results have been obtained with switches rated at both 250v AC 5 amps and 250v AC 15 amps.

The servo and switch have to be positioned so that the switch activating button is pushed in by the servo output disc or arm. To achieve this the switch can be stuck directly to the servo, but before the final bond is made ensure that the action is right.

A far better approach is to fix this switch to an aluminium angle plate which can be attached to the servo with double-side tape or tie wraps. Of course, if room exists, mounting the switch and all the servos on a servo mounting plate is another possibility. The output arm or disc has to be arranged so that the

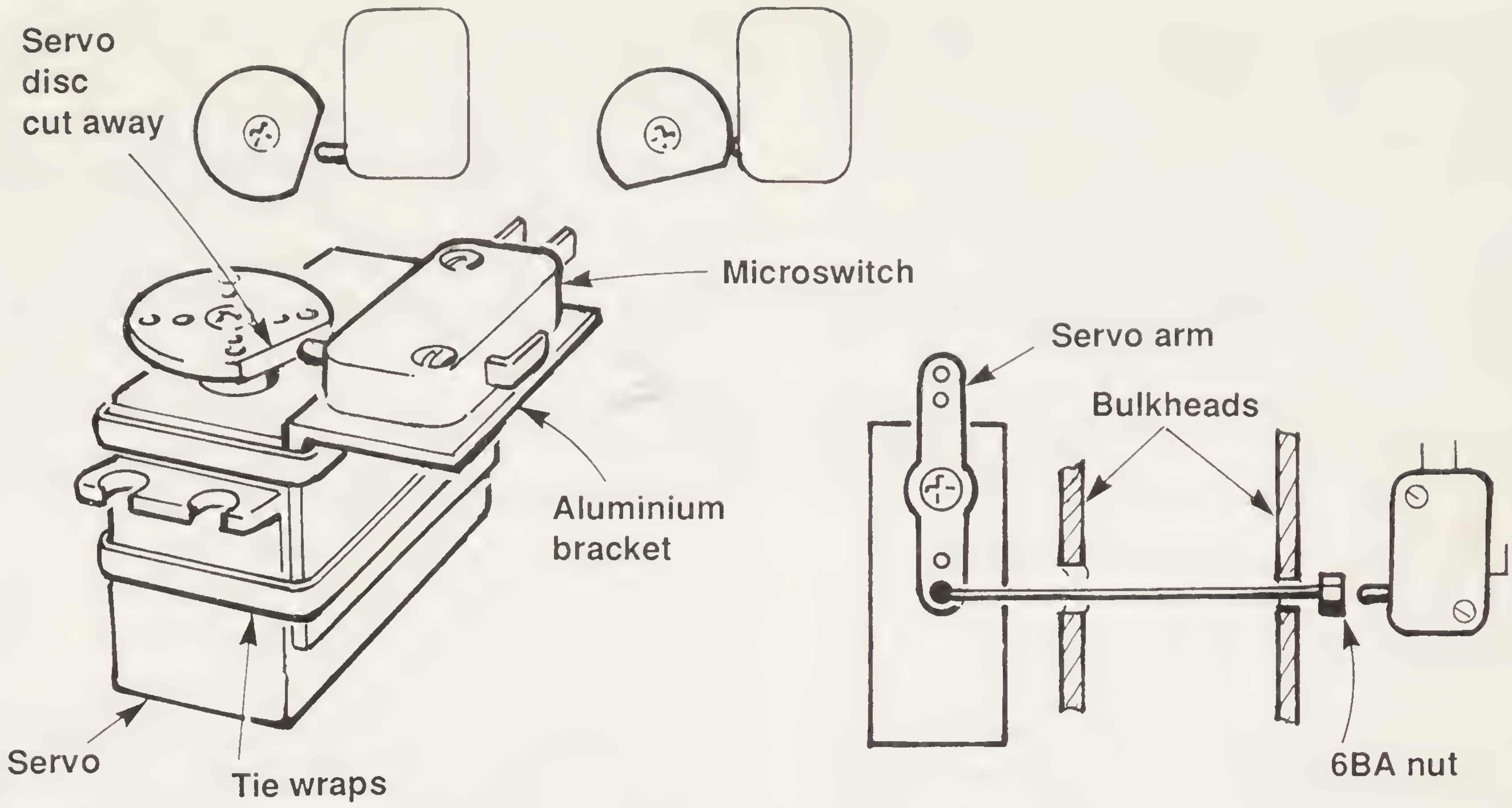


Fig. 7.1 Operation of a microswitch by a conventional servo.

switch is operated at the full travel of the servo. Cutting a gentle cam shape onto a disc is the preferred method and is illustrated. An alternative method is to use an output arm and to arrange things so that the arm pushes in the button at its full travel. It's also possible, though in practice rarely necessary, to mount the servo remote from the switch. Then a pushrod is used to operate the button as shown in the diagrams.

Motor control via mechanical switches is also available to the flier with just two-function radio equipment. This will be arranged to supply elevator and rudder or aileron control but with a little ingenuity can also be arranged to switch the motor on or off too. Full up or down elevator or left or right rudder is used to operate the switch and the diagrams below illustrate the principles. Inevitably a little mechanical juggling will be required to get it just right but, for the patient, satisfactory results are possible.

Electronic Switches

The importers must have been reasonably pleased with our efforts, since for several seasons we continued to display the foam Cessnas at numerous R/C

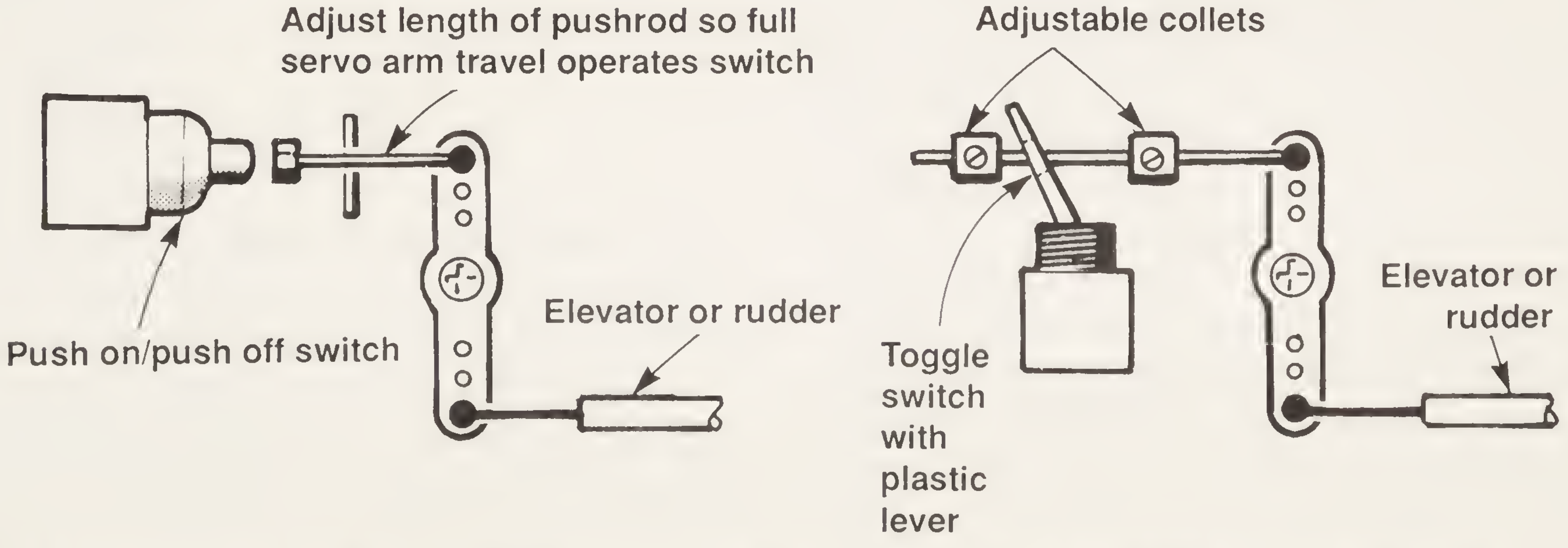


Fig. 7.2 Other forms of servo-operated mechanical switches for use at extreme control positions.

trade shows and fly-ins. Two years after the first display the new season's kits arrived complete with plug-in electronic switches. Inside a neat compact case we found a tiny PCB relay complete with plugs, etc., to suit the Cessna. All we had to do was to plug the relay into the receiver, motor and battery pack and voila! Instant motor control. The exact switching point was adjustable through a tiny hole just big enough to pass a fine screwdriver. The screwdriver turned a miniature potentiometer mounted on the PCB. Control of the motor is via the throttle control on the transmitter and it works in the conventional sense, i.e. the full throttle position on the Tx gives motor on and low throttle, motor off. Switching is positive and three years of use proved the unit reliable.

Today the electric flier is spoiled for choice and a thumb through the ads of your favourite model magazine will reveal a range of electronic switches, some of which allow the receiver battery to be discarded and the 'avionics' powered by the motor battery. A voltage sensor is built into the system and monitors the battery's voltage. When the battery reaches a predetermined low voltage the system switches off all power to the motor, keeping what's left in the battery pack reserved for the avionics. By careful setting of the cut-off point the manufacturer has ensured that enough power is available to effect a safe landing—unless of course you're flying at 600ft and decide to indulge in a little thermal soaring on the way down!

It is not possible to close this chapter on electric flight without a mention of electronic speed controllers. Designed for the R/C car market, these allow infinitely variable speed control as well as forward and reverse. In use such devices absorb power and to avoid power absorption at "full throttle" some manufacturers have incorporated a relay. At the full throttle position the relay cuts out the speed control from the battery to motor circuit allowing full battery power to flow direct to the motor.

Currently there is little need for speed control of this type. As long as the majority of electric models need every ounce of power, such devices must be considered a power-absorbing luxury. Even when technology gives us a surplus of electric power, it is arguable that any of that surplus would be usefully used in providing proportional speed control. Having said that it's interesting to speculate how the electric flier, having fitted such a device, could usefully use the reverse facility!

Chapter 8
Special Considerations for Larger Models

THE *ab initio* visitor to the National Championships or one of the large model symposiums cannot fail to be impressed by the growing number of 'large' models seen at such events. And giant models *are* impressive. They fly smoother and at a more realistic flying speed than their smaller counterparts and are no more difficult to build or fly. The legal definition of a 'large' model is simple. In the U.K., any aircraft weighing more than 5 kgs is subject to the Air Navigation Order. In order that such an aircraft may legally fly, an exemption from that order must be obtained from the Civil Aviation Authority. All that the CAA currently requires is a letter of application giving the following details:

1) Name and address of operator
2) Model type
3) Wingspan
4) Length
5) Weight
6) Engine capacity

The certificates normally take about three weeks to arrive and lay down certain conditions which, if the flight is to remain legal, must be observed.

Generally these are safety requirements and refer to where and how the aircraft may be flown. However, the last condition states that the aircraft must not be flown "unless it is equipped with a mechanism that will cause the said aircraft to land in the event of a failure of its control system, including the radio link, and that such mechanism is in order before the aircraft commences its flight."

The address to write to in the U.K. is:
Civil Aviation Authority, General Aviation Dept., 1st Floor, East Wing, Aviation House, South Area, Gatwick Airport, Gatwick, West Sussex.

For equivalent information in the U.S.A., write to:
Academy of Model Aeronautics, 1810 Samuel Morse Drive, Reston, VA 22090.

Failsafes

The advent of PCM (Pulse Code Modulation) equipment has introduced the built-in failsafe facility. With this system the receiver scans the incoming signal and, in the event of a corruption or loss of signal, causes the servos to run to predetermined positions. It is generally accepted that in order to comply with the legal requirements closing the throttle is sufficient but the prudent modeller may decide to preset other surfaces so that damage in the inevitable crash landing is minimised. PCM, however, is not obligatory.

One-third size Luton Minor flown by Don Luck is 100 in. span, weighs 13¼ lbs and uses an O.S 90 FSR engine.

Add-on failsafe devices are available from the smaller specialist suppliers. These plug in between receiver and servo and again cause that servo to drive to a predetermined position should the radio link fail. Again it would appear that the legal requirements are satisfied by the fitting of such a device to the throttle system only, although, again, the desirability of extending the failsafe to other functions requires careful consideration. Whichever option is taken, failsafes are inexpensive and usually trouble-free in use.

The extra large control surface areas of large models obviously need more effort to move them. One way of supplying this extra power is simply to buy high power servos. Whilst this is undoubtedly one way round the problem it gives no extra protection in the event of servo failure. The failure of one powerful servo controlling the whole of the elevator system will obviously still mean loss of elevator authority. A safer approach would be to use standard servos and "double up", i.e. fit two servos to control a split elevator, and therefore build in an element of redundancy. So having arranged a servo for each half of the elevator, failure of one will leave the pilot with some authority at the rear end and may leave him able to effect a safe landing.

Fast, powerful, large models may require the use of high power servos even using a split system and the prospective builder of such an aircraft or any large model would do well to consult the undoubted expertise of other large model enthusiasts—in the U.K., members of the LMA (Large Model Association) will be happy to advise.

Battery Packs and Backers

As may be seen from the diagram, we have effectively doubled the number of servos in use. Consequently we have almost doubled the load on the battery. Clearly our 500mA pack is now going to be inadequate and consideration has to be given to carrying more amps. The simple way is to change the existing 500mA battery for a 1000mA pack. That

Civil Aviation Authority

Air Navigation Order 1985

EXEMPTION

1 The Civil Aviation Authority, in exercise of its powers under Article 94 of the Air Navigation Order 1985 hereby exempts the radio controlled model aircraft of the following description:

Model Type: Biplane

Wingspan: 2.1m

Length: 2m

Weight: 12kg

Engine Capacity: 35cc

for the time being operated by Mr P D Smoothy and Master C D Smoothy

from all the provisions of the said Order with the exception of Article 47 and Article 48.

2 This exemption is granted subject to the following conditions, namely, that the said aircraft shall not be flown —

(a) in controlled airspace except with the permission of the appropriate air traffic control unit;

(b) in any aerodrome traffic zone except with the permission either of the appropriate air traffic control unit or the person in charge of the aerodrome;

(c) in any airspace to which the Special Rules set out in Rules 36 and 38 of the Rules of the Air and Air Traffic Control Regulations 1985 apply, except with the permission of the appropriate air traffic control unit;

(d) at a height exceeding 400 feet above ground level;

(e) at a distance beyond the visual range of the operators of the said aircraft and in any event at a distance exceeding 500 metres from the operators of the said aircraft;

(f) within 500 metres of any area which is substantially used for residential, industrial or commercial purposes;

(g) within 60 metres of any vessel, vehicle or structure;

(h) within 60 metres of any person other than the operators of the said aircraft or the operator of any other aircraft at the same event;

(i) unless it is equipped with a mechanism that will cause the said aircraft to land in the event of a failure of any of its control systems, including the radio link, and such mechanism is in working order before the said aircraft commences its flight.

3 The exemption shall have effect from the date hereof until and including 31 December 1986 unless previously revoked.

A. Smith

A SMITH
for the Civil Aviation Authority

Date: 3rd March 1986

Distribution:

Reference: 10U/16/01 MPE 841

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will give us the extra capacity we need but still we have no element of redundancy. Battery failure still means a crash and an end to the time and money invested in our model. Having obtained an extra margin of safety by doubling up the servos that theme may be continued by providing some redundancy in the power supply.

The system I use in my Rodel Piper Cub is shown in the diagram. Instead of the usual 1000mA battery packs mentioned earlier, two 500mAh packs are used. Each pack feeds through its own switch harness and a diode effectively prevents cross feeding and maintains the integrity of the system should one pack fail in open or short circuit. The inevitable voltage drop across the diode has been overcome by the addition of one extra cell in each pack, an arrangement which increases the effective voltage to the receiver by just 0.5 volts.

The majority of R/C chargers are the constant current type and will charge five cells just as effectively as four. Of course, unless you have two chargers, each pack has to be charged in turn but the system has proved very reliable in use; of course it's necessary to test each system separately in the preflight checks before switching to both.

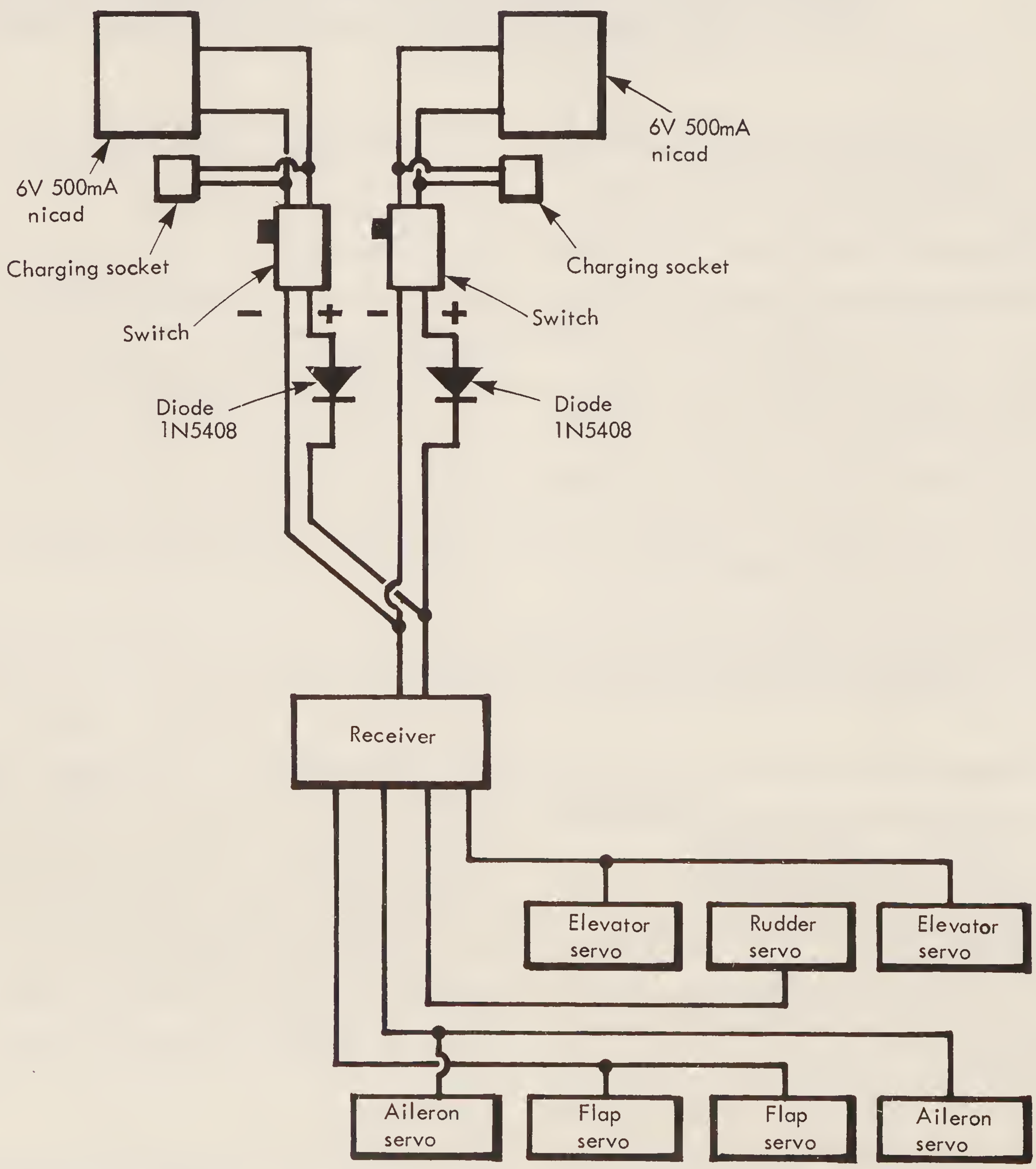


Fig. 8.2 Dual battery pack system used with multiple servos for extra safety with large models.

For those wishing to purchase their dual battery system "off the shelf" then 'battery backers' are the answer. A battery backer is an electronic switch and is plugged in between the battery pack and receiver. Also plugged in is a second, usually smaller, back-up battery. The backer monitors the voltage across the main battery and when this falls to an unsatisfactory level, switches to the back-up battery and indicates, usually via a LED, that the switch has taken place.

Although the back-up battery may be smaller it must have sufficient capacity for at least one flight. A large model with extra servos can be quite demanding and a 500mA pack should be considered the best choice.

It is necessary to check before each flight that the main battery is still OK, but a main battery failure any time after take off should not result in radio failure.

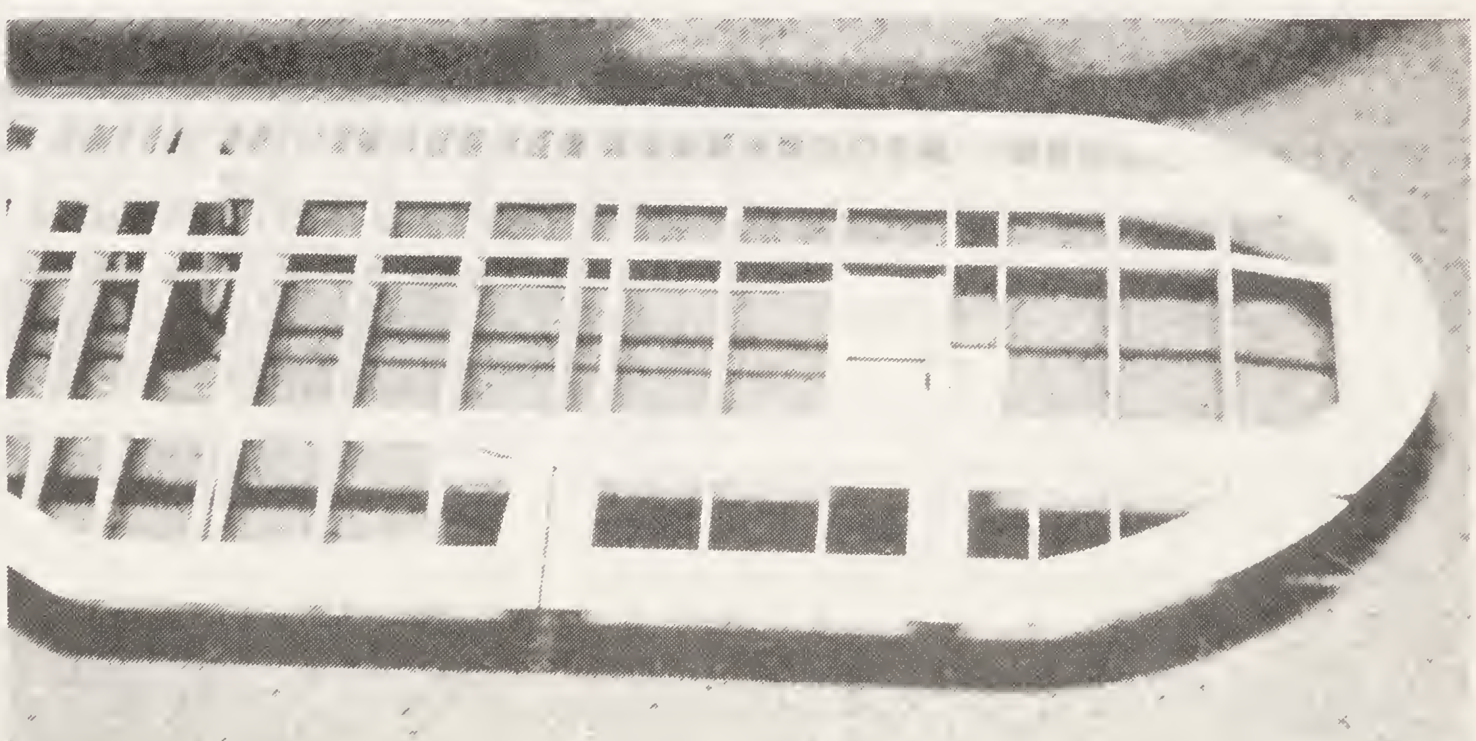
Long Leads and Y Leads

Those extra servos mounted in the wing mean that the standard wing arrangements supplied with the radio will not do. Long extension and 'Y' leads will be required and although initially this may seem daunting they are really quite easy to fabricate with a methodical approach.

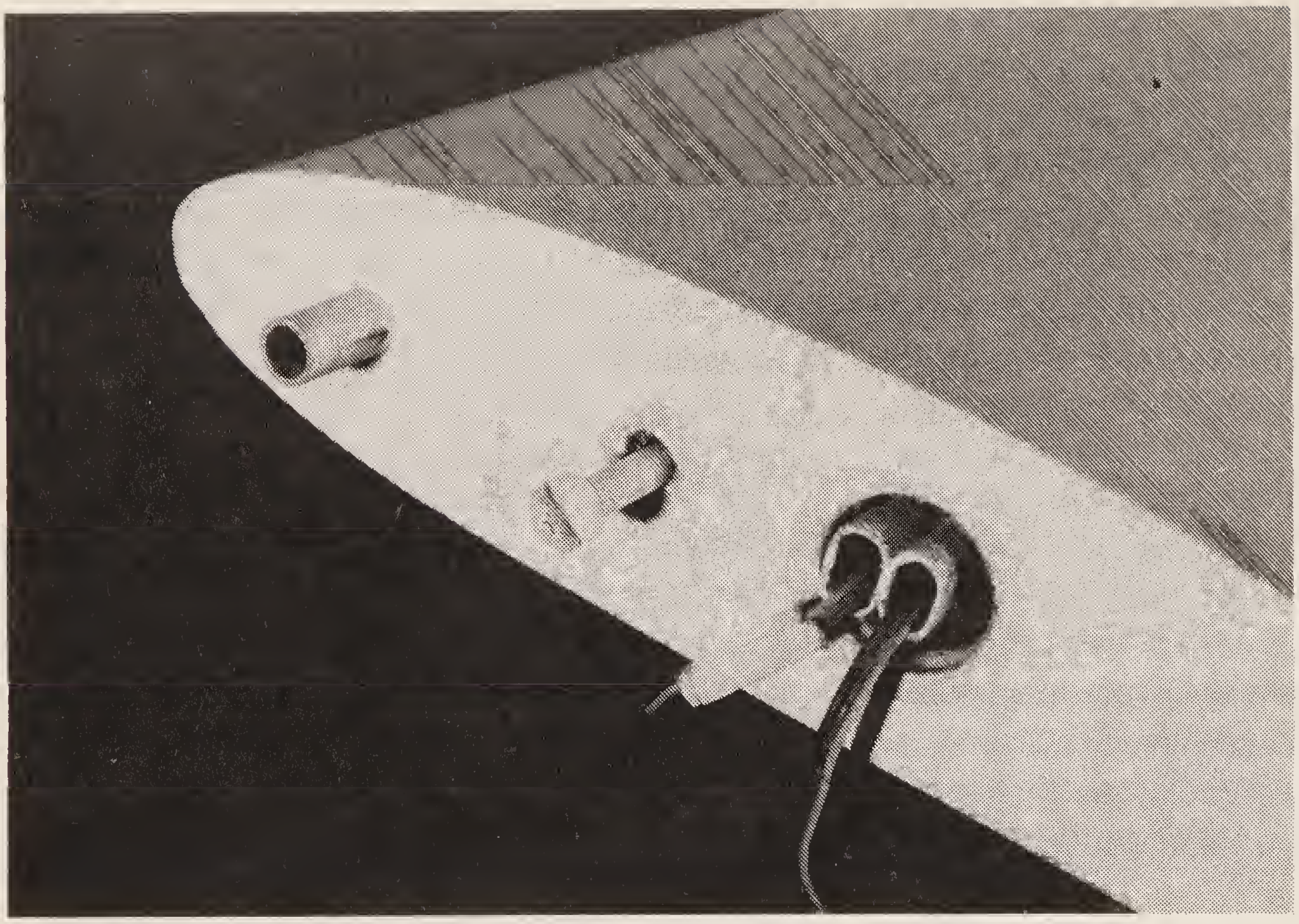
The majority of modern plug and socket connectors used in radio equipment are of the solderless crimped variety. It is not usually possible to buy the plugs, sockets and cable as individual items and if it were, without the crimping tool, the items would be useless anyway.

However, all manufacturers sell aileron leads of standard length and some sell plugs and sockets with a short length of cable already attached. These items will serve as our 'ends'. For the middle section ribbon cable is readily obtainable at electronic components stockists and from the same source heat shrinkable tubing will provide a professional finish. It is of course vital to preserve the integrity of the colour code throughout the harness although the cable used need not match the original. Good soldered joints are essential and an extra pair of hands to hold wires is useful.

Long extension and 'Y' leads are unlikely to be moved from model to model. Indeed, they are better built into wings although on my Cub I did use a plastic conduit that I built into the wing allowing the leads to be removed later.



All parts of large models need to be thought through, for example the stiffness of the aileron pushrods in view of their extra length.



Conduit in the wings of the author's large Cub model allows for removal of the long aileron servo leads.

Do not make leads any longer than is necessary for a neat radio installation. They do radiate and excessively long leads can cause interference. For the same reason avoid running leads parallel or close to the receiver aerial. With care and common sense problems are unlikely but if problems do occur, re-routeing the aerial lead should effect a cure.

It goes without saying that, having made provision for extra servos and more powerful batteries, unless the linkages are adequate failure is still inevitable. Again it's a matter of common sense. Balsa pushrods of *adequate section* will work perfectly in the biggest model, but as large models are also usually scale models, following full-size practice and fitting closed-loop systems is a favourite choice.

Tube and cable systems are available for bigger models and linkages and fittings especially designed for large models are obtainable in both Europe and America.

Large models represent a heavy investment in both time and money but both will be invested well and repaid with interest if attention to detail prevails throughout construction and installation.

Spark ignition and electrical interference

The popularity of spark ignition engines, often converted chainsaw or other small industrial units, in large models has brought with it the problem of interference from the ignition systems. Such interference may indicate its presence by the odd glitch or indeed total loss of control and can be the very devil to track down and eliminate. However, there are a few basic 'golden rules' which should prevent or help eliminate the problem.

Fit a metal shield between the engine and radio. This is best provided by bonding thin aluminium plate to the front side of the engine bulkhead. Litho plate is best and free supplies are probably available from your local printer if the purpose is explained.

The Rx aerial should be routed directly

away from the engine and the receiver mounted away from the engine.

Double check *all* connections, both high and low tension, for security. Pay particular attention to the connection of the HT lead to the spark plug. This can be a continual source of problems if even slightly loose.

Bond the engine casing and engine mount to the bulkhead.

Consider fitting a servo operated micro-switch in the low tension side of the magneto. This will allow the ignition to be cut if problems arise. Useless, I agree, if interference blankets the Rx, but if the servo is failsafe operated it will eliminate the source of interference and allow control to be regained. Operated from a switched function or low throttle it will allow a safe landing if glitches become troublesome.

Electric interference from metal to metal connections has already been mentioned and should be avoided. However, the increasing use of metal fittings on large models means that metal to metal contact is sometimes unavoidable. When this is the case, bonding the two offending items together should eliminate any potential trouble. A flexible braided wire should be soldered across the connection. The diagram shows a throttle connection but the principle is the same for any linkage.

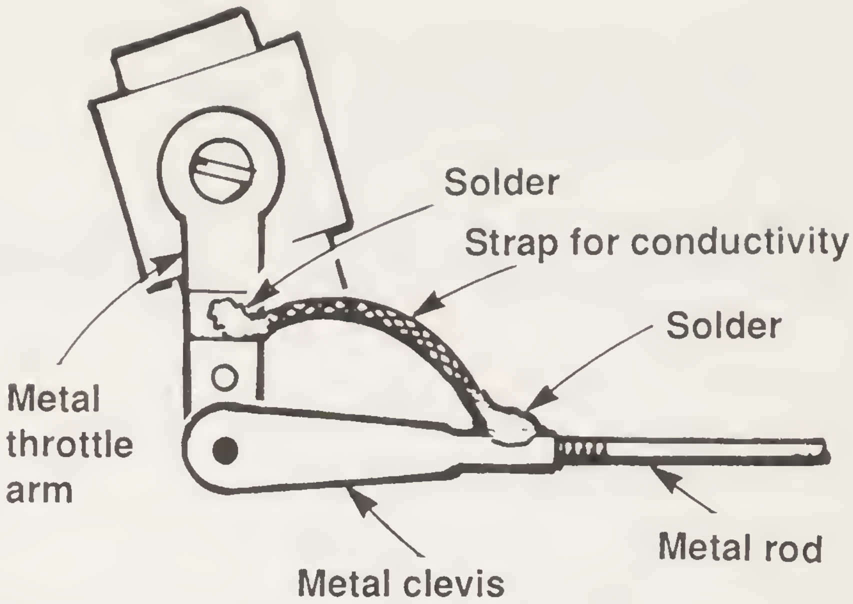
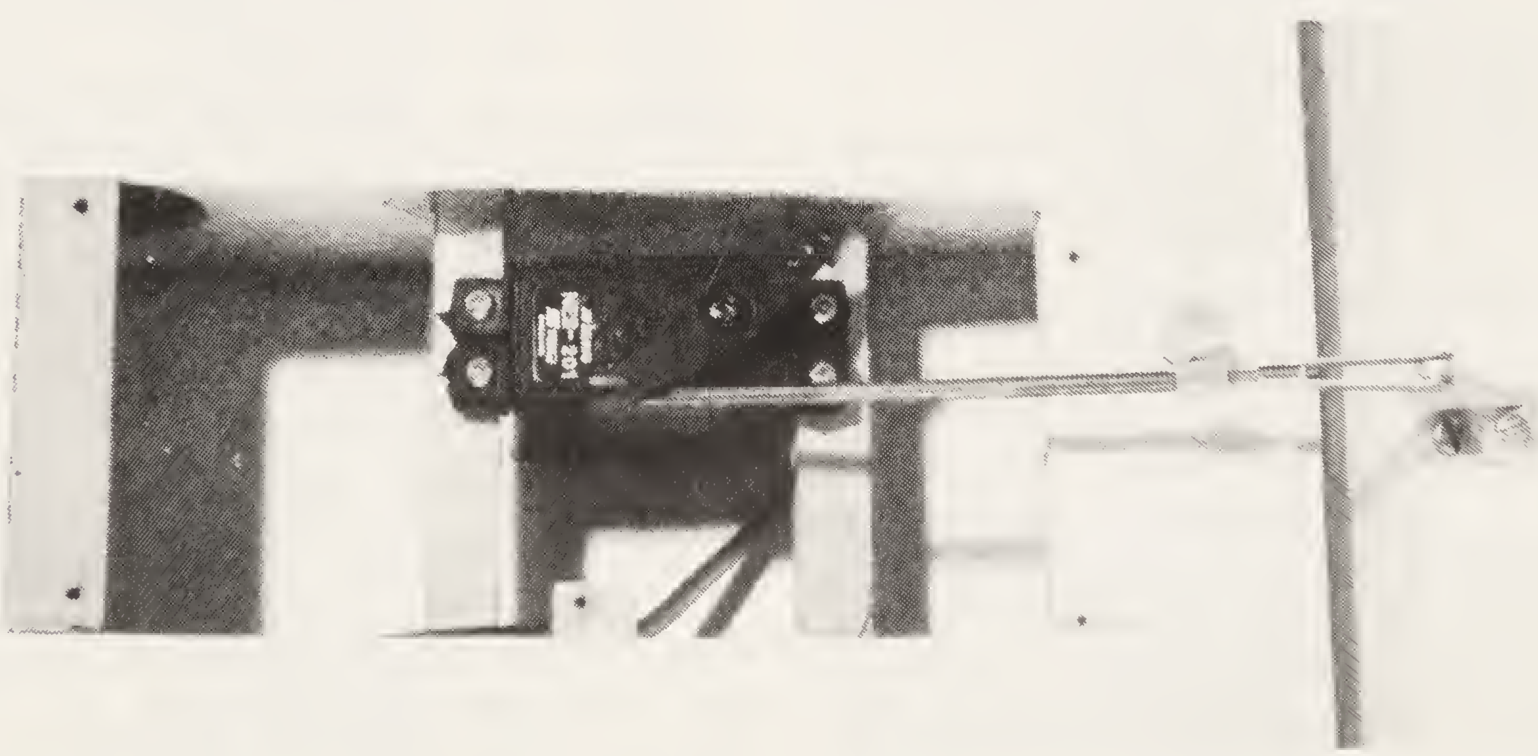


Fig. 8.3 Bonding of connecting metal parts.

Finally, flying models is very much a case of visual perception. Small models tend to be flown much further away. With really large models that distance is beginning to stretch the range of some R/C outfits and weak Tx signals tend to make some receivers more open to interference. So "fly close" and give your radio a chance.



Plenty of room to work is evident in this photo of an aileron servo on a large-scale model. A plate screws over the aperture, of course.

Chapter 9
Dos and Don'ts

IN THIS CHAPTER we list the dos and don'ts of radio installation. They are in no particular order so no store should be placed in where they appear on the list. Some have been mentioned in earlier text, some are new. All are important.

DO join a model club and help yourself to all the free advice so readily available.

DO by all means shop around for R/C equipment but remember, if someone is going to teach you to fly you must have the same basic layout transmitter as your instructor.

DO plan your installation carefully using the model plan as a guide.

DO ensure hinges are aligned before glueing in place and free after glueing!

DO double check everything as you go, leave nothing to be checked later. You may forget, with dire results.

DO protect your airborne equipment from vibration. No items jammed into tight spaces or rats' nests of wires.

DO ensure that connections are not stressed and likely to break or pull apart.

DO route the Rx aerial wire away from servos and metal control runs.

DO avoid metal to metal connections. Metal clevises, for example, connected to metal elevator horns can cause electrical interference by producing electrical 'noise', a phenomemon that is likely when any two metal surfaces vibrate together.

DO ensure that tube and cable systems are adequately supported. Check also that after a period of use they have not become sticky or stiff due to dirt or oil.

DO avoid overtensioning closed-loop systems; too tight and servo wear is inevitable. They don't have to be like guitar strings—just light enough to provide slop-free control.

DO check retracting undercarriage legs for any sign for 'hanging up'. Give

serious consideration to operating mechanical retracts from a separate power supply.

DO thoroughly check your installation before each flying session. Pay particular attention to servo mounting systems, horn and clevis connections and wiring.

DO land immediately at the first sign of trouble. Many radio problems give ample prior warning and disaster may be averted.

DON'T mix radio equipment from different manufacturers without first obtaining expert advice. Servos can usually be interchanged by changing the plug or using a conversion lead but interchanging transmitters and receivers of different types—particularly FM equipment—is fraught with danger.

DON'T try to save money by ignoring signs of impending trouble. If you are not happy with your equipment return it for service explaning exactly what the problem is. If you do have a crash but the equipment appears undamaged send it for service anyway and explain that the equipment has been crashed.

DON'T shorten receiver aerials—or leave them coiled or doubled back. Such action drastically reduces the range of the radio.

DON'T fly with chipped, damaged or unbalanced propellors. Not only are they a danger to you but the vibration caused may seriously affect your radio equipment.

DON'T operate your radio equipment for more than about five minutes with the transmitter aerial retracted. This may overheat and damage the output transistor. Don't forget a quick range check before the first flight of the day. In the absence of manufacturer's instructions to the contrary 30 to 40 paces with the aerial retracted is usually enough to prove the point.

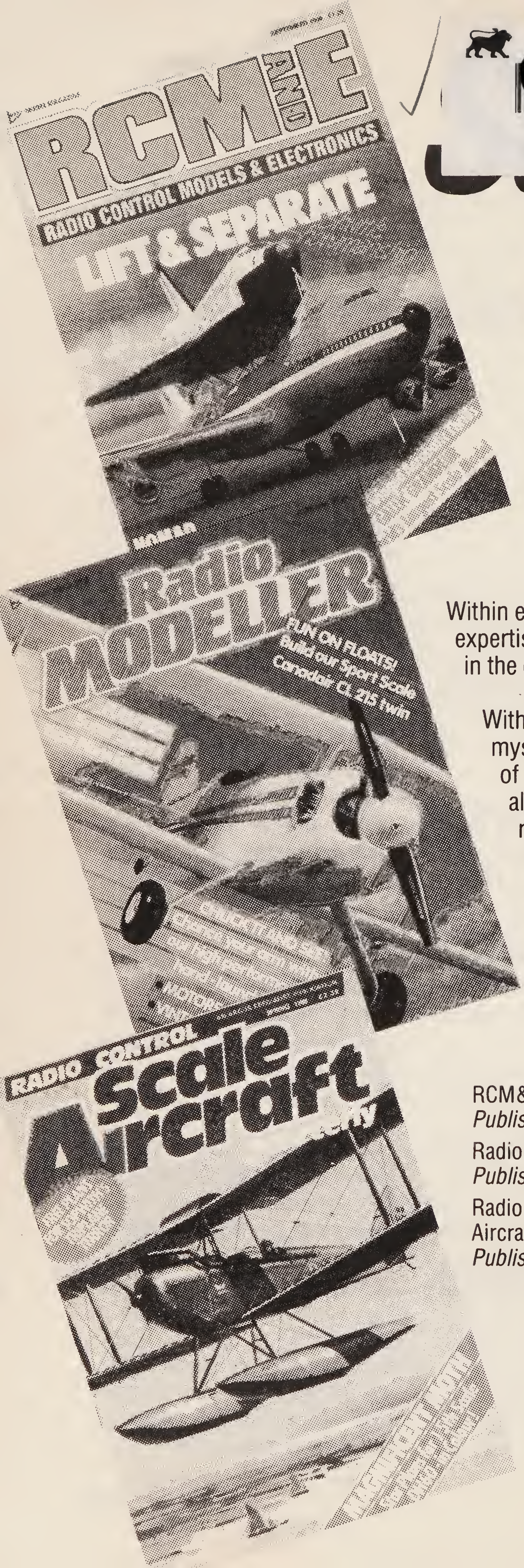
DON'T allow clevis ends to baulk on output arms. Such malpractice causes high current consumption by the servos.

DON'T locate equipment in areas where it may be contaminated by glow fuel without first placing it in a plastic bag for protection.

DON'T allow receivers and battery packs to 'float' around loose in large fuselages. Use polystyrene packing to fill the space followed by foam rubber to provide protection.

DON'T store radio equipment in hot or damp places such as lofts or cellars. However, a cold, dry garage or spare room is ideal.

DON'T bring your radio equipment out of winter hibernation and press it into use without first giving the batteries a 24 hour charge and the whole system a thorough checkover.



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